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LEAF SPOT OF DERRIS[1]

PATERNO R. SANTOS

WITH SIX TEXT FIGURES

Leaf spot is a prevalent disease of derris in the cultures of the Departments of Agronomy and Plant Pathology of the College of Agriculture. The disease occurs also in the Los Baños Economic Garden, Bureau of Plant Industry, the Laguna Provincial Nursery of the same bureau, and on the plants growing on Mount Maquiling.

The disease attacks the leaves chiefly. In any plan to extend derris culture, the leaf spot may become an important disease.

THE DISEASE

History, distribution, and economic importance

In 1908, Hennings described *Phyllosticta derridis* from specimens of derris infected with leaf spot and collected in Africa (Saccardo, 1913). Leaf spot is probably an old disease. It has attracted attention only recently, however, when people began to consider the possibilities of derris as a new export crop of the Philippines. As stated above, the disease is present on derris in the College of Agriculture and in rest of the vicinity of Los Baños, Laguna. Perhaps leaf spot occurs wherever derris is grown.

Counts made of the infected leaves in the field showed that as high as 40 per cent of the foliage may be spotted. In moist, shady places, 60 to 70 per cent of the leaves may be seriously infected.

On July 20, 1940, the writer noted that leaf spot infected 60 to 70 per cent of the leaves of derris in the Laguna Provincial Nursery at Calauan, Laguna.

Although leaf spot is the most widespread disease of derris, it does not kill the infected plants. The efficiency of the leaves to synthesize organic foods, however, is believed to be reduced greatly by the disease.

Leaf spot attacks all of the species and varieties of derris in the College of Agriculture and in the Los Baños Economic Garden throughout the year. Hybrids of *Derris elliptica* (Wall.) Benth. and

[1] Experiment Station contribution No. 1397. Prepared in the Department of Plant Pathology under the direction of Associate Professor G. O. Ocfemia.

other species and strains of *Derris elliptica* and *D. philippinensis* Merr. in the Department of Agronomy are also severely infected with leaf spot.

Symptoms

Early stage of infection. In the early stage of the disease, infection may be noted as minute circular dots hardly a millimeter in diameter, brown, distinct, and visible on both sides of the leaf. The spot may be situated on any part of the expanded portion of the

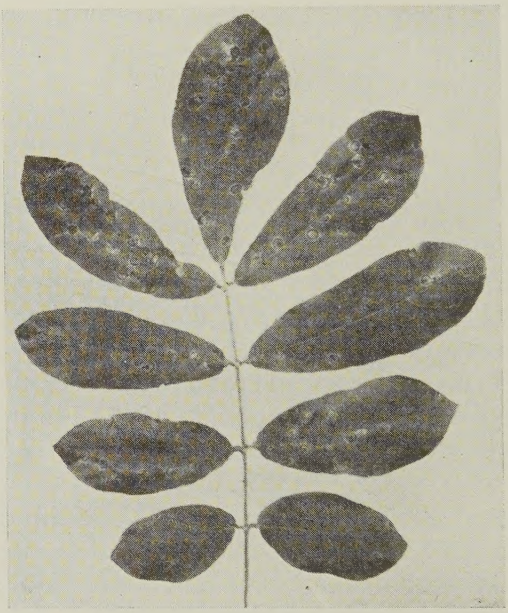

Fig. 1.—An infected leaf of derris showing circular spots caused by *Phyllosticta derridis* P. Henn. surrounded with a ring of yellowish brown tissue. Photograph by the Photographic Division, College of Agriculture.

leaves, including the veins. The minute circular brown spots are surrounded by a band of either transparent, greenish, or yellowish tissue, which is about a millimeter in width (fig. 1). In turn this is surrounded by another band of more or less water-soaked, greenish tissue. The lesions may be present on leaves of different ages. On the young, tender, drooping, greenish or brown leaves, the spots progress very rapidly. Under favorable conditions infection of the tender leaves results in the production of a blight. Usually, however, infection occurs as localized dead areas on the lamina of the

foliage. The majority of the spots are three to four millimeters in diameter. On the veins, especially of the younger leaves, the spots also kill the tissues. Continued growth of the parenchyma around the lesions causes the leaves to assume all forms of distortion (fig. 2). Leaves are readily distorted when several spots coalesce to form larger and more irregular dead areas. The color of these coalesced spots varies from reddish to dirty brown.

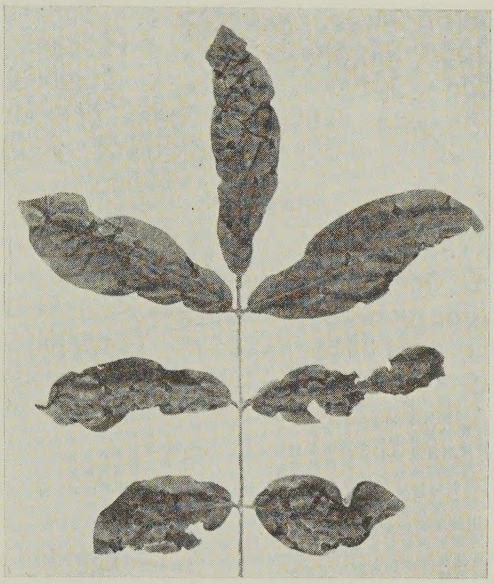

Fig. 2.—An infected leaf of derris showing coalesced spots and a slight degree of distortion of the leaflets. Photograph by the Photographic Division, College of Agriculture.

Advanced stage of infection. In the advanced stage of the disease, isolated spots may be four to five millimeters in diameter, circular, reddish to dirty brown with a distinct brown border about one-third of a millimeter in width. The spots are surrounded by indistinct and diffused yellowish areas. Further growth of the spots on younger leaves and continued growth of the surrounding tissues cause the dry central portion of the lesions to crack or drop off with a shot-hole effect left on the leaves (fig. 2). The spots on the older leaves remain circular in shape, and their dry central region does not break and drop off. They, however, appear grayish brown and thin. In old lesions and during moist weather very minute dark specks may

be seen scattered all over the spots. These are the pycnidia of the causal fungus (fig. 3 *a* and *b*).

CAUSAL ORGANISM

On July 13, 1939, pieces about one-half of a centimeter square were cut with a sharp scalpel from the border of leaf lesions. The squares were immersed in a 1:1000 mercuric bichloride solution from thirty seconds to one minute with constant shaking. The sections were washed in three changes of sterile water in test tubes and plated out on potato-dextrose agar, four squares in each Petri dish. The plates were incubated for twenty-four to forty-eight hours in an upside down position. Fungous growths were noted after 24 hours, but subcultures on agar slants were made 24 hours later. These transfers were used in all subsequent experiments.

Morphology

Mycelium. The hyphae are hyaline, fine, septate, and irregularly branched (fig. 5). One hundred cells of the aërial mycelium of a one week old culture on potato-dextrose agar were 10.20-89.10 × 1.20-5.10 μ; the average was 39.95 × 2.51 μ. The cells of the submerged mycelium were 18.50-300 × 2.55-11.90 μ; the average for 111 cells was 92.18 × 6.59 μ. From these figures it may be seen that the aërial hyphae are finer than the submerged.

Pycnidia. In the field the fungus produced an abundance of pycnidia on the dead areas of the lesions. In pure culture the fungus produced fruit bodies on sterilized derris leaves and on sterilized tissues of plants, especially those belonging to the Leguminosae.

In order that the distribution of the pycnidia on the host might be studied, diseased tissues were treated in two ways. In one, sections 2 × 10-15 millimeters were cut out from typical lesions on leaves of inoculated plants and from sterilized leaves on which the fungus was grown. The sections were killed and fixed in a solution containing 5 millileters of commercial formalin, 5 millileters of glacial acetic acid, and 90 millileters of 70 per cent ethyl alcohol for twenty-four hours. The sections were softened by placing the vial that contained them in a beaker of boiling water for about ten minutes. With this treatment, the pycnidia were left on the leaves, whereas the superficial mycelium disappeared. After being fixed, the sections were dehydrated in graded butyl alcohol (Chamberlain, 1932) and then stained with iron alum haematoxylin. They were counterstained with either light green or orange G. Other sections were stained with safranin and counterstained with orange G. Both

methods of staining gave good results, although the best preparations were obtained with iron alum haematoxylin counterstained with orange G or safranin-orange G.

In the other method for showing the distribution of pycnidia (fig. 3*a* and *b*), sections of the leaf lesions were killed and fixed in

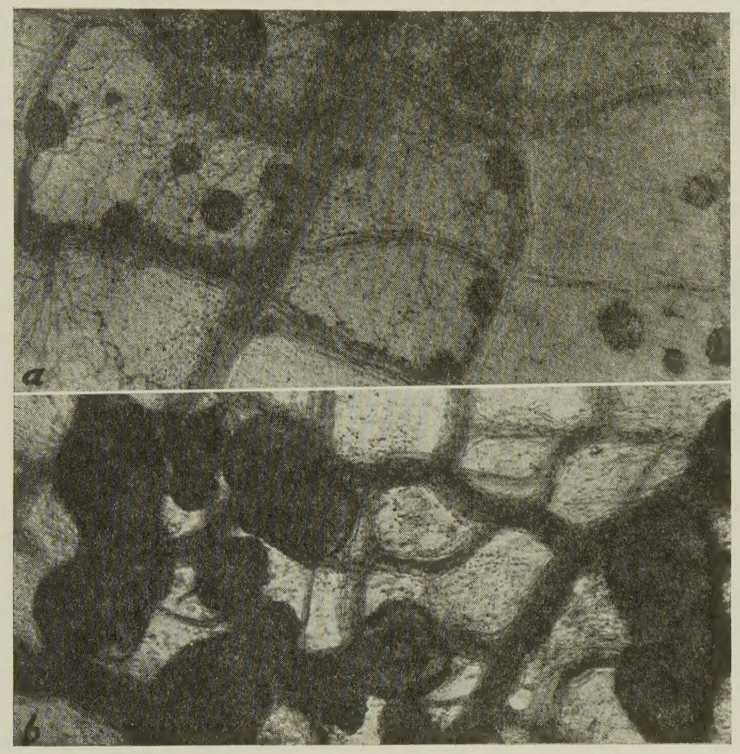

Fig. 3.—Photomicrographs showing (*a*) a portion of an old inoculated derris leaf indicating the distribution of pycnidia and the hyphae radiating from the fruit bodies, × 92; and (*b*) a portion of the sterilized derris leaf on which *Phyllosticta derridis* P. Henn. was grown in a flask showing the shape and the larger size of the pycnidia, and their ostioles, × 92. Photomicrograph by the Photographic Division, College of Agriculture.

formo-aceto alcohol and then cleared in a concentrated solution of KOH for almost a week. The sections were examined daily, and when they were sufficiently clear, they were placed in a short glass tube, both ends of which had pieces of cheesecloth held in place by means of small rubber bands. The tubes were placed in running water from twelve to twenty-four hours until all the fixative and the KOH were removed. The sections were then dehydrated in 10, 30,

50, 70, 80, 95, and 100 per cent ethyl alcohol at the rate of three to four changes a day, cleared in clove oil, and mounted in balsam. The sections were not stained because the pycnidia and the mycelium could be readily seen.

The pycnidia are black, globular to flask-shaped, and have one to three ostioles (fig. 3*a* and *b*). When young, the pycnidia are moist and light brown, but with age they turn black. On the host the pycnidia are formed subepidermally, but at maturity they are erumpent; one-half to two-thirds may be exposed. The pycnidia contain numerous pycnospores (fig. 4) borne on delicate and hyaline conidiophores. Hyphae radiate from the pycnidia in all directions, sometimes,

Fig. 4.—A photomicrograph of a cross section of a pycnidium of *Phyllosticta derridis* P. Henn. showing its contents of pycnospores. × 400. Photomicrograph by the Photographic Division, College of Agriculture.

connecting two or more fruit bodies. Measurements of 118 pycnidia taken from inoculated derris revealed that they are 22.5-217.0 × 45.0-240.0 μ; the average is 101.02 × 138.36 μ. The ostioles are 5.1 to 15.3 μ in diameter; the average is 9.11 μ. The size of 210 pycnidia produced on sterilized derris leaves was 90-275 × 120-570 μ; the average was 177.00 × 267.94 μ. The ostioles of these fruit bodies were 11.25 to 37.5 μ; the average was 21.73 μ. Based on averages, it may be seen that the pycnidia produced on the host under field conditions were smaller. On a substrate consisting of sterilized leaves, the fungus produced pycnidia which were 65.90 × 129.58 μ.

Pycnospores. The pycnospores are small, thin-walled, hyaline, ellipsoid to elongate, rounded at the ends (fig. 5), and 4.4-6.4 × 1.6-2.8 μ. The average size of 265 pycnospores was 5.34 × 2.05 μ. The pycnospores produced on inoculated derris were also slightly smaller than those on sterilized plant tissues. The writer believes that the larger size of spores on sterilized substrates may be due to an abundance of readily available food and to the more uniform conditions for growth obtaining in the culture tubes.

Physiology

Production of pycnidia on media and substrates. When the fungus was grown on various media and substrata, the writer noted that pycnidia were produced only on the following substrates: (*a*) pods of *Vigna sesquipedalis* Fruw., (*b*) pepper fruit, (*c*) Kentucky wonder bean pods, (*d*) *Tephrosia candida* (Roxb.) DC. leaves, (*e*) cowpea leaves, (*f*) cowpea pods, (*g*) soybean leaves, and (*h*) sterilized derris leaves.

To prepare the sterilized derris leaves into a substrate, the writer took young, soft, reddish leaves and washed them in running water for about ten minutes to remove foreign matter adhering to their surfaces. A cotton ball, about three centimeters in diameter, was placed in a 250 ml. Erlenmeyer flask, and a little tap water was poured in to wet the ball and keep the flask moist for a long time. Two to three washed derris leaves were tied together with a string and hung inside the flask, almost touching the cotton ball. One end of the string was held against the mouth of the flask by the cotton plug. The flask was autoclaved for 30 minutes at 15 lbs. pressure, cooled, inoculated with a 3-day old culture of the fungus, and incubated at room temperature.

After five days the fungus produced an abundance of pycnidia. They were deep brownish drab [2] when young and turned black when mature. The substratum changed from rood's brown to avellanous. In old culture, the entire surface was almost covered with black pycnidia.

From the culture on sterilized derris leaves, pycnidia and pycnospores for measurements were obtained.

The media and substrates on which the fungus did not produce pycnidia were: (*a*) potato-dextrose agar, (*b*) derris-decoction agar (prepared in the same way as potato-dextrose agar except for a decoction from two hundred grams of derris leaves and young

[2] RIDGWAY, R. 1912. Color standards and color nomenclature. 43 p., *53 colored pl.; 1115 named colors.* Washington, D. C.

stem instead of potato, twenty grams of dextrose, and twenty grams of agar in one liter of water), (*c*) water agar, (*d*) oatmeal agar, (*e*) steamed corn meal, (*f*) steamed oatmeal, (*g*) steamed rice grains, (*h*) gabi tuber, (*i*) steamed soybeans, (*j*) potato plugs, (*k*) eggplant

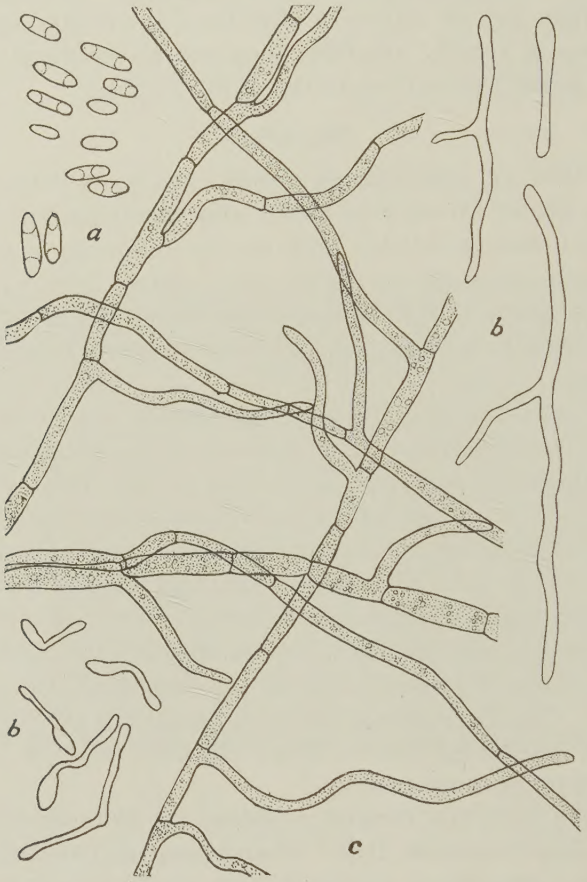

Fig. 5.—Mycelium, pycnospores, and germinating pycnospores of *Phyllosticta derridis* P. Henn. drawn by the writer with the aid of a camera lucida. (*a*) Pycnospores, × 1165; (*b*) germinating pycnospores, × 820; and (*c*) mycelium, × 540.

fruit, (*l*) lettuce petiole, (*m*) pechay petiole, (*n*) sterilized avocado fruit, (*o*) sterilized patola fruit (*p*) sterilized raddish plugs, and (*q*) sterilized ampalaya fruits.

Growth and production of pycnidia on potato-dextrose agar of different hydrogen-ion concentrations. Two liters of potato-dextrose

agar were prepared. The hydrogen-ion concentration of the entire medium was determined with a La Motte color standard comparator and was found to be pH 6.2. Nine equal batches of the medium were placed in Erlenmeyer flasks and plugged with cotton. Ten cubic centimeters of the medium from one of the flasks were poured into each of four Petri dishes. The agar in each of the eight Petri dishes was adjusted to a different hydrogen-ion concentration (table 1). After the reaction of the medium in each flask was brought to the desired pH, ten cubic centimeters of the medium from each flask were poured into each of another four sets of Petri dishes. For each pH, four Petri-dish cultures were prepared.

The Petri dishes were then autoclaved for thirty minutes at 15 lbs. pressure. After sterilization, the hydrogen-ion concentrations of the batches in the flasks and in the Petri dishes were determined. The writer noted that the reactions of the agar in the Petri dishes and in the flasks tallied. The Petri dishes were labelled with the corresponding pH, allowed to cool, and then inoculated with a 3-day old culture of the fungus. The inoculum of more or less the same size was placed in the center of each Petri dish. The plates were incubated in an upside down position at room temperature. After 5 days, the average diameters of the growths of the fungus were measured and recorded (table 1).

The writer noted that the best growth was obtained on the agar with a reaction between pH 5.6 and pH 6.5. There was a thick concentric growth of cottony white aërial hyphae in the Petri dishes. The growth was affected as the acidity was increased above pH 5.6 or reduced below pH 6.5. The fungus grew on the agar with a hydrogen-ion concentration as low as pH 4.4 and as high as pH 7.6, although the growth was much poorer (fig. 6).

The writer noted that the fungus did not produce pycnidia on media of different pH.

Other methods for inducing spore production: (*a*). *Effect upon sporulation of exposure to sunlight of the cut mycelium of the fungus.* The fungus was grown on 5 per cent potato-dextrose agar in Petri dishes (Ocfemia, 1924). At the age of one week and when the fungus covered the entire surface of the Petri dish, the agar and the fungus were cut with a flamed scalpel into pieces about one centi-

meter square. The Petri dishes with their covers tipped slightly to one side to allow escape of moisture were exposed to the sun from five to eight hours. Although the fungus produced stromata-like bodies after 3 days, no pycnidia were formed.

(*b*). *Exposure to a low temperature.* Young cultures of the fungus were placed in an ice box with a temperature of 15°C. for eight to forty-eight hours and then later incubated at room temperature. Although numerous black bodies were produced, no pycnidia were formed.

(*c*). *Immersion of the culture tubes in water.* Test tubes con-

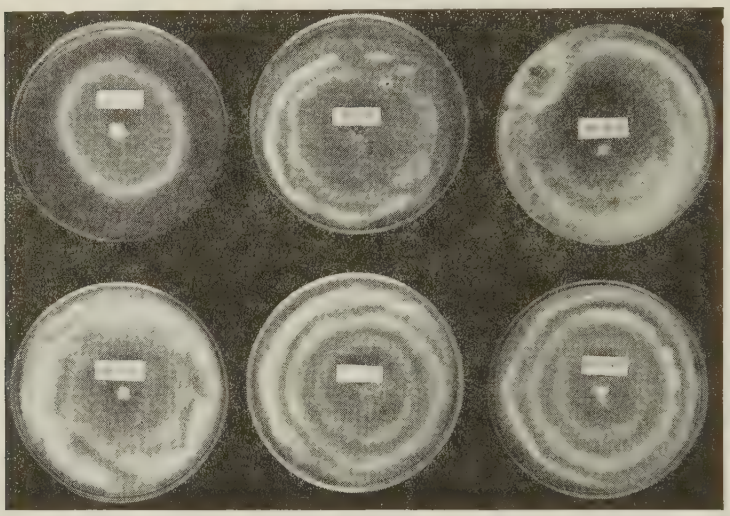

Fig. 6.—The growth of the fungus on potato-dextrose agar adjusted to different hydrogen-ion concentrations. Photograph by the Photographic Division, College of Agriculture.

taining potato-dextrose agar cultures of the fungus were placed in water for one month. Care was taken that their plugs should not get wet. The treatment did not cause production of pycnidia.

(*d*). *Effect on spore-production of growing the fungus in a desiccator.* Three day old cultures were placed in a desiccator and allowed to remain for two to seven days. At the end of this time the cultures were incubated in the laboratory for a month. Black stroma-like bodies were produced, but no pycnidia were formed. The growth of the fungus was the same as that on potato-dextrose agar, which was not subjected to any treatment.

In conclusion it may be stated that the writer's material of *Phyllosticta* on derris produces pycnidia on substrates but not on artificial media. Changes of reaction of the media as well as changes of temperature, moisture, and light did not induce the fungus to produce pycnidia on artificial media.

Studies on pathogenicity

Two methods of inoculation were followed for determining the relation of the fungus to derris. (*a*) The mycelium which contained portions of the medium was smeared on the surface of the leaves of derris. The control plants were smeared with the medium only. (*b*) A suspension of pycnospores in sterile water was sprayed on derris by means of an atomizer. The control was sprayed with sterile water only.

After inoculation, both the inoculated and the check plants were placed in the damp chamber for a period varying from forty-eight hours to seven or more days. From the damp chamber the plants were transferred to a shady place out of doors for further observation. When infection became evident, reisolations were made.

Experiment 1. On July 17, 1939, three plants were inoculated by smearing on their leaves the mycelium of the fungus from pure culture. Symptoms of infection appeared 24 hours after inoculation, and on July 20, 1939, the fungus was reisolated.

Subcultures from the reisolation showed that the fungus was the same as that obtained from the original isolation.

Experiment 2. Three plants inoculated on July 27, 1939, with the pure culture obtained from reisolation showed symptoms of the disease on the young leaves 30 hours after inoculation. After 48 hours, both young and old leaves were infected. The control plants were normal throughout the experiments. On July 31, 1939, the second reisolation was made, and the fungus obtained compared in all respects with the original culture and the culture in the first reisolation.

Experiment 3. Thirty plants were inoculated by smearing on the leaves the young mycelium of the fungus as follows: eight on August 5, ten on August 16, and twelve on August 19, 1939. Of the inoculated plants, 22 were infected, whereas 8 were not. When reinoculated on September 28, 1939, however, all of the 8 plants were infected.

Experiment 4. On October 17, 1939, of the 15 plants inoculated by smearing the fungus on the leaves, 10 were infected in twenty-four to forty-eight hours in the first inoculation. Five plants were used as control. A month later the 5 plants which were not infected were again inoculated, and all of them became diseased after 48 hours. With the smear method, all varieties used were infected.

Experiment 5. On February 6, 1940, pycnospores of the fungus were suspended in water and sprayed on two plants. The inoculated plants and the controls were placed in the moist chamber. One plant showed infection after 4 days, and the other, after 5 days. Reisolation was made on February 12, 1940. With the culture obtained from the reisolation, two plants were inoculated on February 17, 1940, and infection was noted on the following day. The organism obtained from reisolation was the same as the original culture, which was used in the inoculation experiment.

Experiment 6. Of the 9 plants used in inoculation by spraying with a spore suspension on February 20, 1940, only one was not infected. Infection was noted in three days to one week.

Experiment 7. On July 3, 1940, young derris leaves in the experimental plots of the Department of Plant Pathology were sprayed with a pycnospore suspension. In a week to a week and a half, small dots which developed into circular and irregular-shaped lesions appeared. As infection grew older, the lesions enlarged and showed the characteristics of the advanced stages of the disease in the field. Further observations showed that the spots were caused by the same organism.

Cross inoculations to determine range of suscepts

Experiment 1. On January 11 and 12, 1940, seeds of soybean, cowpea [*Vigna sinensis* (Linn.) Endl.], *Tephrosia candida* (Roxb.) DC., mungo (*Phaseolus aureus* Roxb.), *Crotalaria* sp., cotton, roselle, red kidney bean (*Phaseolus vulgaris*), and seedlings of cabbage were planted in cans and pots containing sterilized soil. The plants were inoculated on February 1, 1940, when they had three to four sets of leaves. The cowpea was inoculated first, and on February 3, 1940, infections were noted. Cowpea, soybean, *Tephrosia,* and kidney bean were infected from five to seven days after inoculation. As the symptoms grew older, their characteristics became more apparent, and in some cases the leaves fell.

Experiment 2. On June 18, 1940, corn, melon, watermelon, patola [*Luffa acutangula* (Linn.) Roxb.], peanut, *Talinum patens* Willd., tomato, tobacco, China grass [*Boehmeria nivea* (Linn.) Gaudich.], and papaya were planted. On June 29, 1940, all of the plants were inoculated under controlled conditions. Fifteen hours after inoculation by smearing mycelium on the leaves, the corn, China grass, melon, and tobacco showed symptoms of infection.

In the cross-inoculation experiments the fungus attacked members of the Leguminosae and non-leguminous plants. No infection was obtained on cabbage, mungo, *Crotolaria,* cotton, peanut, and roselle, although the plants were inoculated three times at intervals of about a week.

In the field, the fungus is not known to attack plants other than derris. In artificial inoculation, however, the writer secured infection of 13 species of plants belonging to 12 genera of 7 families. The infection of plants representing other genera and families seems to represent an instance in which susceptibility to the disease is more an expression of the rigorous conditions to which the plants were subjected in inoculation work than of important parasitic relations of the fungus to these plants.

Taxonomy

Hennings' *Phyllosticta derridis* produces pycnidia which are only 60-90 μ in diameter (Saccardo, 1913). On the host in the field, the writer noted that the fungus produced pycnidia which ranged from 22.5 to 217.0 μ in horizontal diameter; the average was 101.02 μ. In vertical diameter the writer noted that the pycnidia ranged from 45.0 to 240.0 μ; the average was 138.36 μ. The ostioles varied from 5.1 to 15.3 μ in diameter; the average was 9.11 μ.

When the writer grew the fungus on sterilized leaves, the pycnidia were 90 to 275 μ in horizontal diameter by 120 to 570 μ in vertical diameter; the average was 177.00 $\times$ 267.94 μ. The ostioles ranged from 11.25 to 37.5 μ in diameter; the average was 21.73 μ. The range of the diameters of the pycnidia described by Hennings is very narrow, and no mention was made of the number of fruit bodies measured. Hennings' maximum figure for the diameter of pycnidia is 11.02 μ smaller than the average obtained by the writer for the horizontal diameter of the fruit bodies from field specimens.

In *Phyllosticta derridis* P. Henn. the pycnospores are 2-2.5 $\times$ 1.5 μ. The pycnospores of the writer's *Phyllosticta* on derris are 4.4-6.4 $\times$ 1.6-2.8 μ; the average is 5.34 $\times$ 2.05 μ. The writer's fig-

ures for the pycnospores are 3.34 μ longer and 0.55 μ wider than those of Hennings'.

The cells of the mycelium on potato-dextrose agar were 10.2 – 89.10 × 1.20 – 5.10 μ for the aërial with an average of 39.95 × 2.51 μ. The submerged hyphae were 18.50 – 300 × 2.55 – 11.90 μ with an average of 92.18 × 6.59 μ.

Discrepancies in size of pycnospores and pycnidia may arise from various causes. In the first place Hennings' materials might have been dry, whereas those of the writer were fresh. The locality from which the fungus was collected and the weather conditions prevailing during the growth of the organism affect the size of the pycnidia and pycnospores. Even with the Philippine materials the writer noted discrepancies in size on different media and substrata. Not much taxonomic significance may be attached to a difference of 11.02 μ in average diameter of pycnidia of a fungus, different strains of which show considerable differences in size when grown on the living host and on sterilized host tissues. Neither can a difference of 3.34 μ in the length and 0.55 μ in the width in favor of the pycnospores of the writer's *Phyllosticta* be considered a sufficient reason for creating a new species for the Philippine fungus. In our inability to refer to Hennings' type specimen for *Phyllosticta derridis* (Hennings, 1908; Saccardo, 1913) for comparing the Philippine *Phyllosticta,* the writer concludes that the organism in question should be identified provisionally with *Phyllosticta derridis* P. Henn.

LIFE HISTORY OF THE CAUSAL FUNGUS IN RELATION TO PATHOGENESIS

Seasonal occurrence of the disease

In the field, leaf spot occurs throughout the year. During the dry months from February to May, however, fewer leaves are attacked by the disease than during the wet season. In the vicinity of Los Baños leaf spot begins to appear at the beginning of the rainy season, and it becomes severe from August to January. Leaf spot is serious during September, October, November, and December.

The disease was noted to be favored by moist cool weather and to develop best in shady places. Under shade it may cause as high as seventy per cent infection of the foliage.

Methods of dissemination

On November 28, 1939, the writer collected leaves of derris heavily infected with *Phyllosticta derridis* P. Henn. The diseased leaves were spread at the bases of potted *Derris elliptica, D. hepta-*

phylla, D. polyantha, and a *Derris* sp., which were collected by the writer from Lanao, Mindanao, in the summer of 1939. The potted derris plants with the dead infected leaves were placed in the moist chamber. Controls without diseased leaves were maintained. Observations were made every day for more than three months. The writer observed that the control plants were not infected with the disease, whereas the plants with rotting infected leaves around their bases were diseased. The result of this experiment seems to indicate that the fungus on infected leaves may be carried to the upper parts of the plants probably by air currents, by insects, or by the water splashed when the plants were watered.

Germination of pycnospores

The pycnospores of *Phyllosticta derridis* germinated in six to fifteen hours on thin layers of potato-dextrose agar on flamed cover glasses held over hollow-ground slides. Each pycnospores produced a germ tube (fig. 5). In about twenty hours, hyphae were well formed and after thirty-six hours the mycelium branched profusely. No pycnidia were produced by the fungus at this stage.

Methods of penetration

Inoculation experiments showed that when spores in suspension in water were sprayed on the leaves of derris, the fungus was capable of penetrating the uninjured young and old foliage. Infection was also obtained when the mycelium was smeared on the nether surface of the leaves. That the fungus is also capable of penetration through the stomata was noted in cross sections made through very young lesions. The writer concludes that the fungus gets into the leaves of derris through natural openings and mechanical injuries on the leaves. Once inside the leaf, the germ tube branches out profusely in all directions.

How the fungus lives through adverse conditions

The fungus lives through adverse conditions on diseased leaves that persist on the plant, on rotting derris leaves on the ground, and possibly on plants which were shown by the cross-inoculation experiments to be susceptible to infection.

CONTROL MEASURES

The measures for the control of leaf spot of derris should not differ from those used for any of the other leaf diseases of plants.

The writer believes that the following suggestions should be of value to the derris grower.

Exclusionary measures

Where the disease has not as yet occurred, careful examination should be made of the planting materials introduced. All infected planting materials should either be disinfected with mercuric bichloride solutions for a few minutes or destroyed at once by burning.

Sanitary measures

Should the disease be introduced into an uninfected area and then become established in the field, it is necessary to keep the field clean. Diseased leaves should be collected and destroyed to reduce sources of inoculum. It is further suggested that derris be planted in the open. The planting of the crop between trees in orchards, under coconut trees on plantations, and with other permanent crops is not advisable.

Inhibition

The reduction of shade of field plantings by thinning trees and shrubs is a good measure for controlling leaf spot by inhibition.

Protection

Inasmuch as the writer did not have at his disposal a large field planting of derris, it was not possible to study the efficiency of Bordeaux mixture prepared with varied proportions of calcium oxide and copper sulfate. Neither was it possible to study the frequency of the application of the fungicide and the practicability of spraying in derris culture. Through the generosity of Assistant Professor Pedro A. David of the Department of Agronomy, the writer was able to test the effect on leaf of monthly applications of Bordeaux mixture on infected derris plants in plantings on a small scale. The infected leaves of heavily diseased plants of the Department of Agronomy were first removed on January 22, 1940. The plants were then sprayed with 4-4-50 Bordeaux mixture on January 23, 1940, and thereafter once a month until September, 1940. Plants situated about thirty meters away from those that were sprayed were maintained as a control for comparison. At the end of the experiment, the control plants had as high as 60 to 70 per cent infection on their leaves, whereas the sprayed derris had only 10 to 20 per cent. The result of the test is far from being conclusive because spraying was done only for a short time, and no effort was made to test the varied

dilution of the fungicide, the varied proportions of the ingredients, and the time of application. The result seems to indicate, however, that infection may be reduced by spraying derris with Bordeaux mixture once a month.

Owing to the continuous appearance of young leaves between spraying time, infection could not entirely be prevented. By varying the time of application and the proportions of the ingredients, the infection may perhaps be reduced to a negligible figure. This assertion is borne out by the fact that leaves that were properly protected during each spraying were entirely free from infection.

The writer believes that, for practical purposes, spraying once a month with standard Bordeaux mixture may reduce infection to such a point that the disease will not cause appreciable damage to the plants. Further work on spraying should give interesting results.

Immunization

All species and varieties of derris used in the different experiments were found to be susceptible to the disease in practically the same degree. For this reason no species or variety may as yet be called resistant to leaf spot.

SUMMARY

1. Leaf spot is a prevalent disease of derris. It occurs throughout the year in the College of Agriculture and in nearby places. The disease is perhaps present wherever derris is grown. Leaf spot may cause infection of as many as 40 per cent of the leaves in open fields and as many as 70 per cent of the foliage in moist, shady places.

2. Young and old leaves of derris are attacked by the disease. The lesions are russet, and they vary in size from small dot-like spots to those involving as much as one-half of the entire leaf. The lesions may be circular to irregular. On old lesions, numerous minute, dark-colored, and erumpent pycnidia may be present.

3. The fungus grows on various media, but it produces pycnidia on a few substrates only. The fungus grew best on potato-dextrose agar with a reaction between pH 5.6 and pH 6.5. The basicity or acidity of the medium had no effect on pycnidium production.

4. In inoculation experiments, infection may be noted 24 hours after the mycelium was smeared on the leaves and 4 days after the spores were sprayed on the plants. In cross-inoculation experiments, infection of 13 species of plants belonging to 12 genera from 7 families was secured.

5. In this work the fungus that causes leaf spot of derris is identified with *Phyllosticta derridis* P. Henn. Its pycnidia and pycnospores are larger than those described by Hennings, perhaps owing to geographical location and environmental conditions prevailing during the development of the fungus.

6. The disease seems to be favored by moist, cool weather, and it develops best in shady places. The spores of the fungus seem to be disseminated by wind, insects, and water splashed from diseased plants. The fungus lives through adverse conditions in the infected tissues of the host.

7. Every effort should be exerted to prevent the entrance and establishment of the disease in new areas. Collecting and destroying the infected materials in field plantings should be rigidly enforced. Thinning of shade may inhibit development of serious disease. Although standard Bordeaux mixture 4-4-50 reduces infection considerably if applied once a month, the practicability of spraying was not studied for want of a large-scale field planting.

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TABLE 1

Diameters of the growth of the fungus on potato-dextrose agar of different hydrogen-ion concentrations taken after six days

CULTURE NUMBER	HYDROGEN-ION CONCENTRATION		INCREASE (+) OR DECREASE (−)	DIAMETER OF GROWTH
	Before sterilization	After sterilization		
	pH	*pH*	*pH*	*mm.*
I	8.0	7.6	−0.4	70.0
II	7.5	7.1	−0.4	85.0
III	7.0	6.5	−0.5	Growth covered entire surface of Petri dish [a]
IV	6.7	6.2	−0.5	Growth covered entire surface of Petri dish [a]
V [b]	6.2	5.6	−0.6	Growth covered entire surface of Petri dish [a]
VI	5.5	5.0	−0.5	85.0
VII	5.0	4.7	−0.3	80.0
VIII	4.6	4.4	−0.2	60.0
IX [c]	4.0	3.8	−0.2	

[a] Diameter of Petri dish (standard size) = 90 mm.

[b] Original pH of medium.

[c] Medium did not solidify owing to hydrolysis of agar by the acid added before sterilization under pressure.

STUDIES ON THE DETERIORATION OF BURNED SUGAR CANE [1]

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Oftentimes sugar cane is burned, either purposely or accidentally, and sometimes it may take two weeks before all the burned cane can be harvested. Burning the cane before cutting facilitates harvesting and reduces the cost of the operation. For varieties with heavy trash, this is almost necessary. It is believed that this treatment does not cause deterioration to the cane provided that it is milled within 24 to 48 hours. Some centrals in the Philippines, however, penalize burned cane as much as 4 to 5 per cent because of the loss in sugar and the trouble produced in the subsequent treatment of the cane juice.

Some sugar men believe that burned cane deteriorates more slowly if left standing and should be harvested only as transportation to the mill becomes available. Others believe that if burned cane is allowed to stand in the field, it loses its sugar content through dilution of contained juices by absorption of soil moisture and development of buds in an effort to maintain life.

A fire caused by burning trash occurred in the cane field of the College of Agriculture Experiment Station on March 16, 1940, at about 2:00 o'clock in the afternoon. About seventy tons of cane were burned. With this material for study, this investigation was conducted with the following objects: (*a*) to determine the rate of deterioration of burned, topped, cut cane; burned, topped, standing cane; and burned, standing cane; (*b*) to determine the rate of deterioration of burned, topped, cut cane under field and mill yard conditions; and (*c*) to determine the rate of loss in weight of burned, topped, cut cane under field conditions.

MATERIALS AND METHODS

In this study two cane fields were used. The first had an area of about a hectare. It was divided into different plots, each of which

[1] Experiment Station contribution No. 1398. Read before the Los Baños Biological Club October 31, 1940.

was planted to the following flowering varieties of sugar cane: C.A.C. 117; C.A.C. 126; C.A.C. 128; and POJ 2878. The second field had an area of about one-fourth of a hectare. It was planted to P.S.A. 14, a non-flowering variety of sugar cane.

The different flowering varieties were each divided into two lots and treated as follows: In lot A the cane was topped and cut on March 17, 1940, and allowed to lie in the field; in lot B, it was allowed to stand in the field without any treatment until harvested; it was then analyzed.

The non-flowering variety of sugar cane was divided into three lots, which were treated as follows: In lot A, the cane was topped and cut and left in the field; in lot B, it was topped and left standing in the field; and in lot C, it was allowed to stand in the field without any treatment. There were four replications in each treatment. In order to determine the rate of deterioration of burned cane under mill yard conditions, about two tons of C.A.C. 117 were topped and cut soon after the cane had been burned and hauled to the U. P. Sugar Mill.

The composite samples from the different lots were analyzed daily until the end of the experiment. The canes were crushed separately in the College sugar cane hand mill. A composite sample of the crushed juice from each treatment was analyzed, and the degree Brix and percentage of polarization were determined.[2] From these data the apparent purity and piculs sugar per ton of cane of each treatment were determined by Warren's table in *Chemical Control for Sugar Factories* published in 1921 by the Association of the Hawaiian Sugar Technologists.

In order to determine the rate of loss in weight of burned cane, exactly 200 kilograms of newly topped and cut P.S.A. 14 were weighed and left lying in the field. They were weighed daily until the end of the experiment.

RESULTS AND DISCUSSION

The results of this study are presented in tables 1-6.

Effects of the different treatments at harvesting of burned flowering varieties of sugar cane

Table 1 shows the analysis and yield of sugar per ton of cane of the different varieties under the different treatments. It will be seen in this table that, as a whole, not much appreciable change oc-

[2] The analyses were made with the help of Mr. Leopoldo J. Villanueva of the Department of Agricultural Chemistry.

curred in the apparent purity of the juice and in the yield of sugar per ton of cane during the first four days after the cane was burned, whether the cane was cut or left standing in the field. Five days after the cane was burned, however, a very marked decrease in the purity of the juice and yield of sugar per ton of cane was noticed in all of the four varieties of sugar cane under the different treatments. These results corroborate the findings of Locsin (1923), who reported that in five days, burnt cane lost 26.47 per cent sugar. Calma (1935) also reported that when the cane was topped, burned, and allowed to stand in the field, the loss in piculs sugar per ton of cane at the end of five days amounted to an average of 32.1 per cent.

Table 2 shows the comparative average yield of piculs sugar per ton of cane of the different varieties under the different treatments. This table shows that in all of the different varieties, no statistical difference occurred in the yield of sugar per ton of burned, topped, cut cane and burned, standing cane. These results indicate that after a flowering variety of sugar cane was once burned, there was no appreciable difference in the losses of sugar whether the cane was cut or allowed to stand in the field. This was probably due to the fact that little or no sucrose inversion resulting from the metabolic processes and especially from the development of the buds took place, because the cells of the cane were ruptured and broken down by the heat of the fire. Undoubtedly, the heat generated by the fire killed some and possibly all of the cells and buds of the cane.

Table 3 shows the comparative average yield of sugar per ton of P.S.A. 14 cane under the different treatments. It is interesting to note in this table that even eleven days after the cane was burned, there was no appreciable change in the yield of sugar per ton of cane. This may be due to the fact that this cane does not produce much trash, and, therefore, the stalks were not thoroughly burned, unlike in the four flowering varieties of sugar cane studied. In fact, eleven days after the fire, mold, so commonly found in the flowering varieties used in this study, was not found on the stalks. During the first four days after the cane was burned no appreciable difference in the yield of sugar per ton of cane between the different treatments occurred (table 3). Five days after burning, however, the cane that was allowed to stand in the field showed greater loss of sugar per ton of cane than either the topped and cut, or topped, standing cane. The differences in the yield of sugar per ton of cane five days after the fire between either the topped and cut or the topped, standing cane, on the one hand, and the standing cane without any treatment, on the other, were statistically significant. Topping and cutting immediate-

ly after burning might have prevented rapid deterioration owing to enzymes being present in the tender part of the cane.

These results agree with the findings of Hind (1921) and Calma (1935), who reported that deterioration of burned cane was less rapid when the cane was cut than when it was left standing with the tops attached to the stalk. From the standpoint of the central and grower, it would be an advantage to cut burned non-flowering cane as there would be less sugar loss than if it were allowed to stand in the field. No significant difference, however, occurred in the yield of sugar per ton of cane between topped and cut and topped, standing cane.

Table 4 shows the comparative analysis of burned, topped, and cut sugar cane under field and mill yard conditions. It is interesting to note in this table that a very marked decrease occurred in the apparent purity and piculs sugar per ton of cane five days after the cane had been burned in both treatments. This table also shows that in all determinations without any exception the cane under field conditions had a higher apparent purity and better quality ratio than the cane under mill yard conditions.

Table 5 shows that the cane under field conditions gave statistically a higher yield of sugar per ton of cane than that under mill yard conditions. This might be due to the fact that the large pile of cane in the mill yard increased the temperature in the cane and increased also the humidity because of diminished aeration; all these conditions favored the breaking up of sucrose into fermentable hexoses by bacterial and fungoid growths of the cane and enzymes in the juice.

Table 6 shows the loss in weight of burned, topped, and cut sugar cane. In the weight of the cane, there was a gradual loss, which ranged from 3.5 to 20.5 per cent.

In the present study, attempts were made to determine the effects of different treatments at harvesting upon the yield of burned sugar cane. The results reported in this paper were obtained under field conditions from about seventy tons of flowering and non-flowering varieties of sugar cane, sufficiently large to make the conclusions drawn from the study fairly reliable.

SUMMARY AND CONCLUSIONS

1. Whether the cane was cut or left standing in the field, not much appreciable change occurred in the apparent purity of the juice and in the yield of sugar per ton of cane during the first four

days after it had been burned. Five days after the cane was burned however, a very marked decrease in the purity of the juice and yield of sugar per ton of cane was noticed in all of the flowering varieties of sugar cane studied.

2. After a flowering variety of sugar cane was once burned, no appreciable difference occurred in the losses of sugar whether the cane was topped and cut or allowed to stand in the field.

3. In the case of a non-flowering variety of sugar cane, no appreciable difference occurred in the yield of sugar per ton of cane between the different treatments during the first four days after the cane had been burned. Five days after burning, however, the cane that was allowed to stand in the field showed a greater loss of sugar per ton of cane than either the topped and cut or the topped, standing cane.

4. The burned, topped, and cut sugar cane under field conditions had a higher apparent purity and better quality ratio than that under mill yard conditions.

5. In the weight of the burned, topped, and cut sugar cane, there was a gradual loss, which ranged from 3.5 to 20.5 per cent.

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TABLE 1

The analysis and yield of piculs sugar per ton cane of the varieties under the different treatments

VARIETIES	TREATMENTS	DATE ANALYZED	TIME FROM TREATMENTS TO ANALYSIS	CRUSHER JUICE ANALYSIS			PICULS SUGAR PER TON CANE	
				C. Brix	Pol.	Ap. purity	Yield	Difference
		March, 1940	*days*	*degree*	*per cent*	*per cent*	*piculs*	*piculs*
P.O.J. 2878	Cut	18	1	19.11	17.59	92.04	2.134	
	Standing	18	1	17.61	15.13	85.91	1.752	0.382
	Cut	19	2	18.58	16.63	89.50	2.008	
	Standing	19	2	18.41	17.16	93.21	2.103	–0.095
	Cut	20	3	16.55	13.46	81.32	1.502	
	Standing	20	3	20.38	17.78	87.24	2.103	–0.601
	Cut	21	4	20.80	17.78	85.48	2.087	
	Standing	21	4	19.00	16.77	88.26	2.008	0.075
	Cut	22	5	21.09	18.86	79.94	1.881	
	Standing	22	5	12.99	14.11	78.43	1.534	0.347
	Cut	23	6	23.73	17.94	75.53	1.897	
	Standing	23	6	19.39	15.23	78.54	1.660	0.237
	Cut	24	7	19.43	15.01	77.25	1.628	
	Standing	24	7	18.23	13.11	71.91	1.328	0.300
	Cut	25	8	23.51	15.94	67.80	1.534	
	Standing	25	8	18.22	12.14	66.63	1.138	0.396
C.A.C. 117	Cut	18	1	17.45	16.26	93.18	2.024	
	Standing	18	1	17.08	16.12	94.37	1.976	0.048
	Cut	19	2	17.84	15.79	88.50	1.881	
	Standing	19	2	16.52	15.96	96.61	2.008	–0.127
	Cut	20	3	20.42	19.07	93.38	2.324	
	Standing	20	3	15.24	12.43	81.56	1.391	0.933
	Cut	21	4	19.86	17.37	87.46	2.055	
	Standing	21	4	16.90	14.88	88.04	1.771	0.284
	Cut	22	5	18.99	14.49	76.30	1.549	
	Standing	22	5	15.09	13.57	89.92	1.644	–0.095
	Cut	23	6	19.19	15.89	82.80	1.802	
	Standing	23	6	17.09	12.46	72.90	1.296	0.506
	Cut	24	7	18.73	13.67	72.98	1.423	
	Standing	24	7	19.73	13.61	68.98	1.344	0.079
	Cut	25	8	24.94	17.06	68.40	1.660	
	Standing	25	8	16.73	11.24	67.18	1.075	0.585
C.A.C. 126	Cut	18	1	17.20	15.41	89.59	1.866	
	Standing	18	1	17.14	15.21	88.73	1.818	0.048
	Cut	19	2	17.74	14.45	81.45	1.628	
	Standing	19	2	15.70	12.16	77.45	1.328	0.300
	Cut	20	3	17.52	14.68	83.78	1.673	
	Standing	20	3	19.82	17.70	89.30	2.103	–0.430
	Cut	21	4	19.10	16.58	86.80	1.945	
	Standing	21	4	19.10	14.41	75.44	1.534	0.411

TABLE 1 (continued)

VARIETIES	TREATMENTS	DATE ANALYZED	TIME FROM TREATMENTS TO ANALYSIS	CRUSHER JUICE ANALYSIS			PICULS SUGAR PER TON CANE	
				C. Brix	Pol.	Ap. purity	Yield	Difference
		March, 1940	*days*	*degree*	*per cent*	*per cent*	*piculs*	*piculs*
	Cut	22	5	20.79	13.80	66.37	1.312	
	Standing	22	5	16.69	12.41	74.35	1.312	0.000
	Cut	23	6	20.49	13.20	64.42	1.217	
	Standing	23	6	16.79	13.02	77.54	1.549	—0.332
	Cut	24	7	22.73	13.35	58.73	1.087	
	Standing	24	7	18.53	13.60	73.39	1.407	—0.320
	Cut	25	8	24.82	15.56	62.69	1.377	
	Standing	25	8	15.12	19.59	63.35	0.857	0.520
C.A.C.	Cut	18	1	17.34	14.49	86.33	1.755	
128	Standing	18	1	16.20	15.54	95.92	1.929	—0.174
	Cut	19	2	16.54	14.22	85.79	1.660	
	Standing	19	2	15.34	14.64	89.59	1.755	—0.095
	Cut	20	3	20.38	18.61	91.38	2.261	
	Standing	20	3	15.55	11.85	76.20	1.267	0.994
	Cut	21	4	18.66	13.48	72.24	1.375	
	Standing	21	4	18.05	14.37	77.67	1.565	—0.190
	Cut	22	5	19.22	16.56	86.16	1.945	
	Standing	22	5	14.79	12.63	85.39	1.470	0.475
	Cut	23	6	20.49	14.41	70.32	1.439	
	Standing	23	6	17.99	14.50	80.60	1.613	—0.174
	Cut	24	7	20.93	13.27	63.40	1.189	
	Standing	24	7	17.56	11.87	67.59	1.122	0.067
	Cut	25	8	15.07	11.06	73.39	1.138	
	Standing	25	8	22.52	16.96	75.31	1.802	—0.664

TABLE 2

The comparative average yield of piculs sugar per ton of cane of the different varieties under the different treatments

VARIETIES	NO. OF REPLICATIONS	AVERAGE YIELD			STANDARD DEVIATION	VALUE OF "Z"
		Cut	Standing	Difference		
		piculs	*piculs*	*picul*		
POJ 2878	8	1.833	1.703	0.130	0.4498	0.2895 (Insignificant)
C.A.C. 117	8	1.839	1.563	0.276	0.3492	0.7934 (Insignificant)
C.A.C. 126	8	1.513	1.488	0.025	0.4650	0.0537 (Insignificant)
C.A.C. 128	8	1.595	1.565	0.030	0.4691	0.0640 (Insignificant)

TABLE 3

Comparative average yield of piculs sugar per ton of cane under the different treatments
(P. S. A. 14)

TREATMENTS	DATE ANALYZED	TIME FROM TREATMENT TO ANALYSIS	AVERAGE YIELD OF SUGAR PER TON CANE	
			Yield	Difference
	March, 1940	*days*	*piculs*	*picul*
Cut [a]	18	1	2.237 ± 0.018	
Topped	18	1	2.162 ± 0.054	0.075 ± 0.058
Standing	18	1	2.087 ± 0.041	0.150 ± 0.044
Topped [b]	18	1	2.162 ± 0.054	
Standing	18	1	2.087 ± 0.041	0.075 ± 0.068
Cut [a]	19	2	2.067 ± 0.023	
Topped	19	2	2.095 ± 0.049	−0.028 ± 0.054
Standing	19	2	2.158 ± 0.037	−0.091 ± 0.043
Topped [b]	19	2	2.095 ± 0.049	
Standing	19	2	2.158 ± 0.037	−0.063 ± 0.061
Cut [a]	20	3	2.110 ± 0.029	
Topped	20	3	2.071 ± 0.018	0.039 ± 0.033
Standing	20	3	2.095 ± 0.026	0.015 ± 0.038
Topped [b]	20	3	2.071 ± 0.018	
Standing	20	3	2.095 ± 0.026	−0.024 ± 0.031
Cut [a]	21	4	2.134 ± 0.054	
Topped	21	4	2.162 ± 0.020	−0.028 ± 0.058
Standing	21	4	2.091 ± 0.031	0.043 ± 0.062
Topped [b]	21	4	2.162 ± 0.020	
Standing	21	4	2.091 ± 0.031	0.071 ± 0.036
Cut [a]	22	5	2.008 ± 0.021	
Topped	22	5	2.079 ± 0.027	−0.071 ± 0.033
Standing	22	5	1.952 ± 0.029	0.056 ± 0.036
Topped [b]	22	5	2.079 ± 0.027	
Standing	22	5	1.952 ± 0.029	0.127 ± 0.039
Cut [a]	23	6	2.063 ± 0.030	
Topped	23	6	2.088 ± 0.013	−0.020 ± 0.032
Standing	23	6	1.909 ± 0.038	0.154 ± 0.049
Topped [b]	23	6	2.088 ± 0.013	
Standing	23	6	1.909 ± 0.038	0.174 ± 0.040
Cut [a]	24	7	2.051 ± 0.057	
Topped	24	7	2.000 ± 0.032	0.051 ± 0.064
Standing	24	7	1.853 ± 0.007	0.198 ± 0.057
Topped [b]	24	7	2.000 ± 0.032	
Standing	24	7	1.853 ± 0.007	0.147 ± 0.033
Cut [a]	25	8	1.814 ± 0.024	
Topped	25	8	1.881 ± 0.014	−0.067 ± 0.088
Standing	25	8	1.739 ± 0.035	0.075 ± 0.042
Topped [b]	25	8	1.881 ± 0.014	
Standing	25	8	1.739 ± 0.035	0.142 ± 0.036

TABLE 3 (continued)

TREATMENTS	DATE ANALYZED	TIME FROM TREATMENT TO ANALYSIS	AVERAGE YIELD OF SUGAR PER TON CANE	
			Yield	Difference
		days	*piculs*	*picul*
Cut [a]	26	9	2.150 ± 0.030	
Topped	26	9	1.984 ± 0.029	0.066 ± 0.042
Standing	26	9	1.742 ± 0.059	0.408 ± 0.066
Topped [b]	26	9	1.984 ± 0.030	
Standing	26	9	1.742 ± 0.059	0.242 ± 0.066
Cut [a]	27	10	2.042 ± 0.045	
Topped	27	10	2.040 ± 0.014	0.002 ± 0.047
Standing	27	10	1.901 ± 0.035	0.141 ± 0.057
Topped [b]	27	10	2.040 ± 0.014	
Standing	27	10	1.901 ± 0.035	0.139 ± 0.038
Cut [a]	28	11	1.968 ± 0.024	
Topped	28	11	2.015 ± 0.033	−0.047 ± 0.041
Standing	28	11	1.790 ± 0.039	0.178 ± 0.046
Topped [b]	28	11	2.015 ± 0.033	
Standing	28	11	1.790 ± 0.039	0.225 ± 0.051

[a] Cut was used as the basis for comparison.
[b] Topped was used as the basis for comparison.

TABLE 4

The comparative analysis of C.A.C. 117 sugar cane under field and mill yard conditions

TREATMENTS	DATE ANALYZED	TIME FROM TREATMENTS TO ANALYSIS	CRUSHER JUICE ANALYSIS		Ap. purity	PICULS SUGAR PER TON CANE	
			C. Brix	Pol.		Yield	Difference
	March, 1940	*days*	*degree*	*per cent*	*per cent*	*piculs*	*picul*
Field	19	1	17.84	15.79	88.50	1.881	
Mill yard .	19	1	17.72	15.41	86.96	1.818	0.063
Field	20	2	20.42	19.07	93.38	2.324	
Mill yard .	20	2	17.51	14.43	82.41	1.644	0.680
Field	21	3	19.86	17.37	87.46	2.055	
Mill yard .	21	3	19.24	15.26	79.31	1.676	0.379
Field	22	4	18.99	14.49	76.30	1.549	
Mill yard .	22	4	18.12	13.62	75.16	1.439	0.110
Field	23	5	19.19	15.89	82.80	1.802	
Mill yard .	23	5	20.09	13.51	67.24	1.281	0.521
Field	24	6	18.73	13.67	72.98	1.423	
Mill yard .	24	6	19.20	12.60	65.62	1.171	0.252
Field	25	7	24.94	17.06	68.40	1.660	
Mill yard .	25	7	17.65	10.70	60.62	0.913	0.747

TABLE 5

The comparative average yield of piculs sugar per ton of cane of C.A.C. 117 under field and mill yard conditions

NUMBER OF REPLICATIONS	AVERAGE YIELD			STANDARD DEVIATION	VALUE OF "Z"
	Field	Mill yard	Difference		
	piculs	*piculs*	*picul*		
7	1.813	1.420	0.393	0.2487	1.584 (Highly sig.)

TABLE 6

The loss in weight of burned topped and cut P.S.A. 14 sugar cane

DATE WEIGHED	ORIGINAL WEIGHT OF CANE	LOSS IN WEIGHT OF CANE	
	kgm.	*kgm.*	*per cent*
March 18, 1940	200		
19	193	7	3.50
20	186	14	7.00
21	184	16	8.00
22	176	24	12.00
23	172	28	14.00
24	165	35	17.50
25	163	37	18.50
26	159	41	20.50

THE USE OF ALCOHOL AS FUEL FOR FARM ENGINES [1]

ALEJANDRO B. CATAMBAY [2] AND SAWAENG KULTHONGKHAM [3]
Of the Department of Agricultural Engineering

WITH FIVE CHARTS

Although alcohol has long been manufactured in large sugar centrals in the Philippines, it was not given a practical trial as a motor fuel until 1922 when it was used as fuel for tractors. The operators then were satisfied provided the tractor ran. At that time, little or no effort was directed toward determining fuel economy. Alcohol is made from molasses, and, therefore, the operators of the sugar centrals were glad to have an outlet for this by-product. Although extensive experiments have been conducted on the use of alcohol as fuel for automotive engines, very little work has been done on its use as fuel for single cylinder stationary engines, which are now found on many farms in the Islands. These engines were originally designed to use gasoline as a starting fuel and kerosene as a running fuel. Owners of such engines will probably be interested to know how they will perform with alcohol and kerosene-alcohol mixtures as fuels.

Object of the present work

The object of the present study was to determine the feasibility of using commercial ethyl alcohol and alcohol-kerosene mixtures in different proportions as fuels for some farm engines.

The experimental work was started in June, 1939, and was finished in May, 1940. All tests were conducted in the laboratory of the Department of Agricultural Engineering.

MATERIALS AND METHODS

Engines and their specifications

The four engines used in this study were the following:

1. International, 1½ h.p. (single cylinder)
   Bore, 3⅝ inches
   Stroke, 4½ inches

[1] Experiment Station contribution No. 1399.
[2] Assistant Professor of Agricultural Engineering.
[3] Thesis student who performed most of the experimental work in this study.

Compression ratio, 4.19 : 1
Rated speed, 500 r.p.m.
Pulley: diameter, 7 inches
Fuel tank: capacity, 15/16 gallon (U.S.)
Water hopper: capacity, 2¼ gallons (U.S.)
This engine was acquired by the College on June 3, 1925.

2. International, 3 h.p. (single cylinder)
Bore, 4½ inches
Stroke, 5½ inches
Compression ratio, 4.16 : 1
Rated speed, 600 r.p.m.
Pulley: diameter, 8 inches
Fuel tank: capacity, 1-7/10 gallons (U.S.)
Water hopper: capacity, 3¾ gallons (U.S.)
This engine was acquired by the College on November 24, 1931.

3. International, 6 h.p. (single cylinder)
Bore, 4¾ inches
Stroke, 8 inches
Compression ratio, 4.15 : 1
Rated speed, 550 r.p.m.
Fuel tank: capacity, 3⅜ gallons (U.S.)
Water hopper: capacity, 8 gallons (U.S.)
This engine was acquired by the College on November 11, 1922.

4. International tractor ("Farmall 12," four cylinders)
Engine: Drawbar power, 9.44 h.p. Belt power, 13.45 h.p. Bore, 3 inches.
Stroke, 4 inches. Compression ratio, 4.30 : 1.
Belt pulley: speed, 800 r.p.m.; diameter, 12⅜ inches.
Carburetor: International, downdraft type.
Size, 1 inch.
Fuel system: tank capacity, 13 gallons (U.S.)
Fuel supply to carburetor, by pump operated from camshaft.
Air cleaner: I.H.C., oil washed, wire filter type.
Cooling system: thermo-siphon. Capacity, 3½ gallons (U.S.)
Clutch: 9-inch, single disc, 195 lbs.-ft. torque capacity.
Transmission: forward speeds—2.27, 2.98, and 3.84 m.p.h. Reverse—2.28 m.p.h.
Belt pulley: diameter, 12⅜ inches; 800 r.p.m.
This engine was acquired by the College on March 11, 1938.

Fuels

Kerosene. The kerosene used in all tests for all engines had an average specific gravity of 0.801.

Ethyl alcohol. Commercial ethyl alcohol bought from La Tondeña, Inc., Manila, (190° proof) was used for the tests on the 1½ and 3 h.p. engines. It has an average specific gravity of 0.821.

Mixture A. This fuel is a mixture of 50 parts by volume of kerosene, 50 parts of commercial ethyl alcohol, and 25 parts of castor oil. Kerosene and ethyl alcohol do not mix without castor oil in the proportion mentioned above. Castor oil was added little by little until a stable mixture was obtained. Twenty-five parts by volume of castor oil were the minimum requirement to stabilize the mixture at a room temperature of about 27°C.

Mixture B. This mixture is made of 25 parts by volume of kerosene, 75 parts of ethyl alcohol, and 25.8 parts of acetone. Acetone was used as the stabilizer.

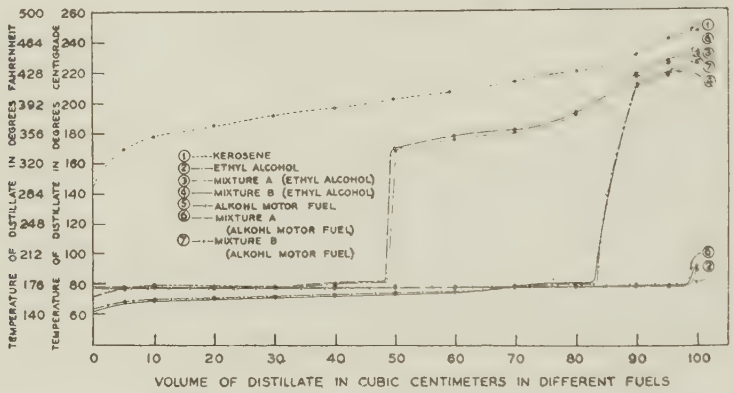
TEMPERATURE OF DISTILLATE IN DEGREES FAHRENHEIT
TEMPERATURE OF DISTILLATE IN DEGREES CENTIGRADE
500 464 428 392 356 320 284 248 212 176 140
260 240 220 200 180 160 140 120 100 80 60
①—KEROSENE
②—ETHYL ALCOHOL
③—MIXTURE A (ETHYL ALCOHOL)
④—MIXTURE B (ETHYL ALCOHOL)
⑤—ALKOHL MOTOR FUEL
⑥—MIXTURE A (ALKOHL MOTOR FUEL)
⑦—MIXTURE B (ALKOHL MOTOR FUEL)
0 10 20 30 40 50 60 70 80 90 100
VOLUME OF DISTILLATE IN CUBIC CENTIMETERS IN DIFFERENT FUELS

Chart 1.—Showing relation between temperature and volume of distillate from different fuels.

Alkohl motor fuel. In conducting the test with the 6 h.p. and the tractor engines, Alkohl motor fuel [4] was used instead of commercial ethyl alcohol. It was also used in preparing mixtures A and B for these engines.

Gasoline. Gasoline was used only as a starting fuel for all engines.

A summary of some of the physical properties of the fuels used in the experiment is shown in table 1.

Testing apparatus

The Froude D. P. × 4 hydraulic dynamometer was used in all tests. It was manufactured by Heenan & Froude, Ltd., Worcester, England. A shaft to which a 12-inch pulley was keyed was joined

[4] Alkohl motor fuel—100 parts by volume of 95 per cent ethyl alcohol + 5 parts by volume of gasoline.

to the dynamometer shaft by means of a coupling. The shaft to which the pulley was attached was supported by two Dodge-Timken self-aligning roller bearings. This dynamometer could absorb a maximum of 150 h.p. at from 1200 to 4000 r.p.m. The engines were hitched to this apparatus one at a time by means of a 6-inch canvas belt.

The computed horsepower does not include belt losses. In order to minimize slippage, belt dressing material was applied to the belt every time the load was changed.

A hand tachograph was used in determining the r.p.m. of the engine and the shaft of the dynamometer. It consists of a stop watch and a revolution counter which operate at the same time, thereby recording the time and number of revolutions made within the period of determination. The stop watch read to the nearest 1/5 of a second.

In determining the fuel consumed by the engine within the period of test, another stop watch was used to record the time. It read to the nearest 1/5 of a second.

The fuel consumption was measured with a Toledo bench scale No. 565805, which has a maximum capacity of 25 pounds and reads to the nearest 0.01 pound. It has a fan-like dial and a pointer which swings from the right side to the left as the load on the platform decreases.

Adjustments of testing appliances

Before the test was started, each engine was thoroughly checked. Old carburetor and cylinder head gaskets of the single cylinder engines were replaced with new ones. The main and connecting rod bearings were examined to check tightness. Fuel pumps were cleaned. Water jackets of the single cylinder engines were drained and flushed before the hopper was filled with clean tap water. The radiator of the tractor used in the test was also drained and flushed before it was filled with clean tap water. The valves and ignition timing were adjusted according to the manufacturer's specifications. New oil and grease were used in lubricating bearings and other moving parts.

The dynamometer and pulley shafts were properly aligned before the experiment was started. Before each test, grease was forced into all bearings, and then the grease cups were filled. The support of the dynamometer weights was removed, and the indicator on the circular dial was set to zero. Water with sufficient pressure from the College water line was admitted into the dynamometer. The

amount of water flowing through it was controlled by means of a valve placed before the outlet.

The Toledo scale was leveled by means of a spirit level attached to it. The portable fuel tank was placed on the platform of the scale and connected to the suction pipe of the fuel pump of the engine used in the test. The excess fuel flowed back into the fuel tank through a piece of rubber tubing connected to the carburetor's overflow pipe. The amount of fuel used by the engine within a certain period of test was determined by noting the difference between the readings on the scale before and after the test. The time of the test was determined by a stop watch.

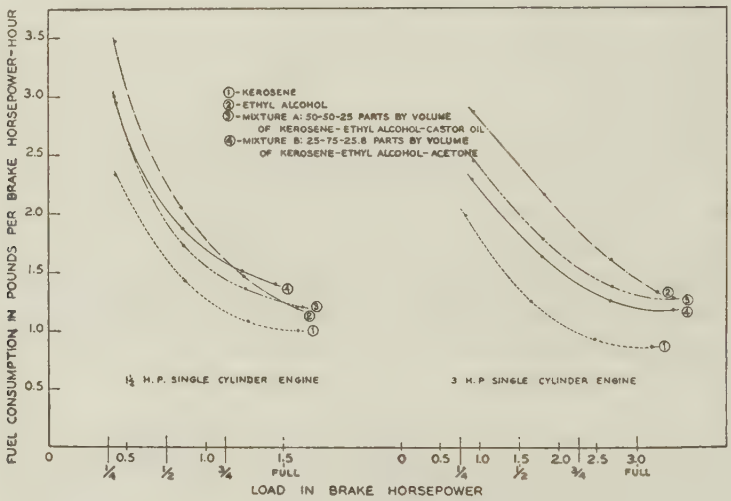

Chart. 2.—Showing relation between fuel consumption and load in brake horsepower.

Procedure of tests

The power of the engine was transmitted to the dynamometer by a 6-inch canvas belt. The belt tension was adjusted by moving the engine away from the dynamometer pulley. The engine platform was constructed to permit this adjustment. In order to minimize belt slippage, belt dressing material was applied to the belt before a test was started. The engine was started with gasoline and then switched to the fuel being tested. Sufficient time was given to warm up the engine before starting any test. With the carburetor needle valve adjusted to a minimum opening which gave the engine the highest constant speed, the maximum power it could develop was determined. From the maximum weight registered in the dynamo-

meter dial while the engine was developing maximum power or full load, the one-fourth, one-half, and three-fourth loads were computed. All tests were started from full load going down to one-fourth load. For the purpose of checking the results, tests were also conducted the reverse way, that is, starting from one-fourth load and going up to full load.

Before each engine was started, the governor was adjusted to give the throttle valve the maximum opening.

The amount of fuel consumed by the engine was determined every three minutes from the difference of two consecutive readings on the Toledo scale. Ten readings constituted a test for one load of each fuel. While the fuel consumption was being measured, the r.p.m. of engine and dynamometer were also determined. Any trial made with a fluctuation of 10 revolutions of the engine and dynamometer shafts from the normal r.p.m. for a given load was discarded.

All tests were conducted on a clear day. In order that the experiment would be subjected to practically the same weather conditions, no test was made on rainy and cloudy days.

Distillation of fuels

Fuels were distilled in order to get an estimate of their volatility. The A.S.T.M. method D 86-27 was followed in the distillation.

RESULTS AND DISCUSSIONS

General observation

Starting of the engines. Only straight commercial ethyl alcohol, Alkohl motor fuel, and mixture B were able to start cold engines. With kerosene and mixture A as fuels, the engines were started with gasoline, and when sufficiently warmed up, they were shifted to these fuels. According to Brown,[5] a cold motor may be started and kept running without difficulty by the proper use of the choke if the 10 per cent point on the A.S.T.M. distillation curve does not exceed the temperature obtained from the expression, 1.25 (100 + Engine temperature, °F.). The average temperature of the cold engines was 75°F. and with the above formula applied, the resulting temperature is 218.8°F., or 103.8°C. As shown in table 2 and illustrated in chart 1, the temperatures of the first 10 per cent distilling of the fuels with the exception of kerosene are lower than 103.8°C. Mixture A which contained castor oil, however, was not able to start cold engines.

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[5] BROWN, G. G. 1930. The volatility of fuels. Michigan Engin. Res. Bull. 14: 299. *Fig. 1-110.*

Operation. The engines performed satisfactorily on all fuels once they were sufficiently warmed up. Engine detonation with kerosene fuel was discernible at three-fourths load and became more pronounced as the load was increased to full. It was eliminated when water was injected with the fuel.

Mixture A was found to be exacting as to carburetor adjustment. Any slight disturbance in an adjustment for a specific load caused a sudden drop in the engine speed.

It was noted that alcohol had a wider range of flexibility. The carburetor adjustment may be slightly altered without noticeable

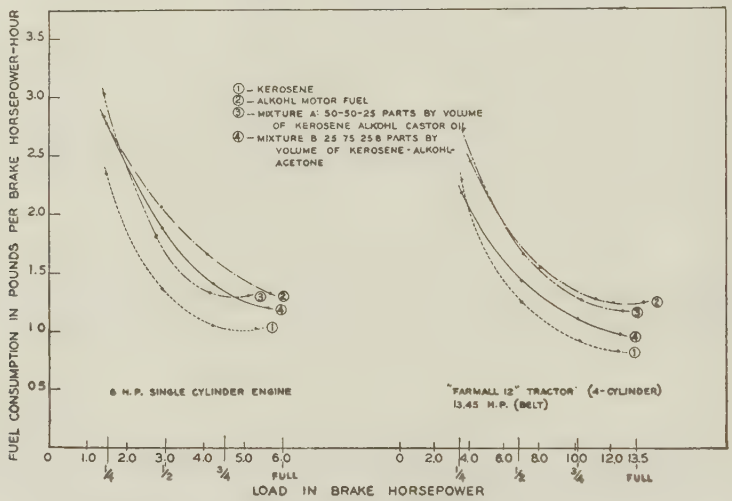
FUEL CONSUMPTION IN POUNDS PER BRAKE HORSEPOWER-HOUR
3.5
3.0
2.5
2.0
1.5
1.0
0.5
①– KEROSENE
②– ALKOHL MOTOR FUEL
③– MIXTURE A: 50-50-25 PARTS BY VOLUME OF KEROSENE ALKOHL CASTOR OIL
④– MIXTURE B 25 75 25 8 PARTS BY VOLUME OF KEROSENE - ALKOHL- ACETONE
6 H.P. SINGLE CYLINDER ENGINE
"FARMALL 12" TRACTOR (4-CYLINDER) 13.45 H.P. (BELT)
0 1.0 2.0 3.0 4.0 5.0 6.0
¼ ½ ¾ FULL
0 2.0 4.0 6.0 8.0 10.0 12.0 13.5
¼ ½ ¾ FULL
LOAD IN BRAKE HORSEPOWER

Chart. 3.—Showing relation between fuel consumption and load in brake horsepower.

change in the engine performance. Proper carburetor adjustment should, therefore, be determined in order to secure the power desired with the least fuel consumption.

The exhaust gases from mixture A were characterized by an offensive odor. They were very irritating to the eyes and throat. A gummy substance collected in the spark plug during the test with this fuel.

The cooling water of all single cylinder engines boiled during the tests. The maximum temperature of the cooling water of the tractor engine was 82°C. A radiator and fan in the system gave more effective cooling; these prevented the water from boiling.

Maximum power developed by the engines

The 1-1/2 h.p., 3 h.p., and tractor engines developed maximum power higher than the rated power. The 6 h.p. engine developed a maximum of only 5.74 horsepower, which was 4.33 per cent less than the rated power.

The 1-1/2 h.p. engine developed 1.62 horsepower with mixture A, which was 8.00 per cent over the rated. With ethyl alcohol the

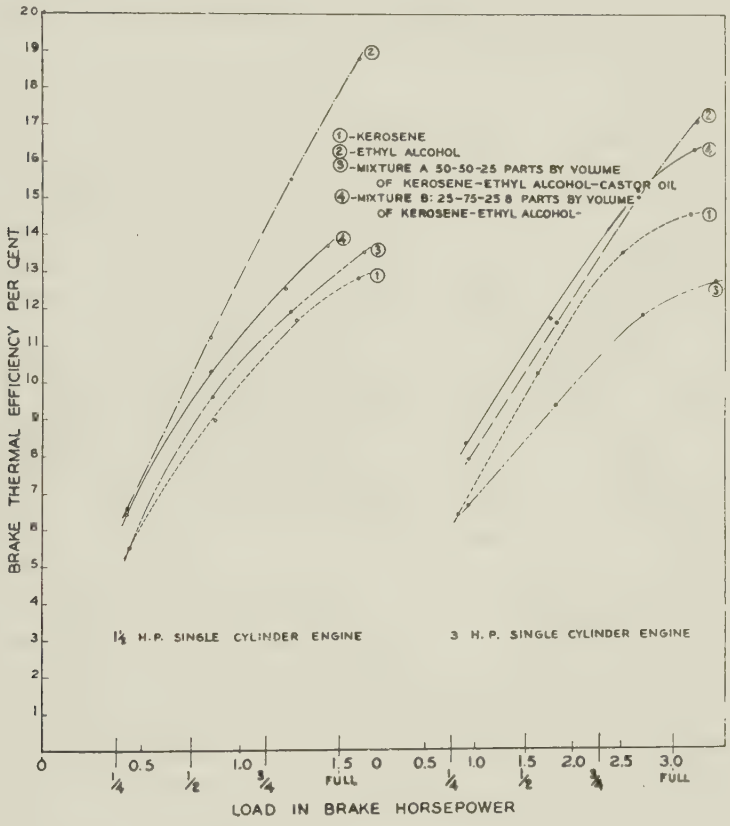
BRAKE THERMAL EFFICIENCY PER CENT
①-KEROSENE
②-ETHYL ALCOHOL
③-MIXTURE A 50-50-25 PARTS BY VOLUME OF KEROSENE-ETHYL ALCOHOL-CASTOR OIL
④-MIXTURE B: 25-75-25 8 PARTS BY VOLUME OF KEROSENE-ETHYL ALCOHOL-
1¼ H.P. SINGLE CYLINDER ENGINE
3 H.P. SINGLE CYLINDER ENGINE
FULL
FULL
LOAD IN BRAKE HORSEPOWER

Chart. 4.—Showing relation between brake thermal efficiency and load in brake horsepower.

power developed was 1.61 horsepower, which was slightly lower than with mixture A. The 3 h.p. reached a 3.46 horsepower maximum with both mixtures A and B, which was 15.33 per cent higher than the rated power.

The maximum power developed by the 6 h.p. engine with Alkohl motor fuel was lower than the rated power, perhaps because it was

an old engine. This result conforms with that found by Cruz and Ang [6] when they used the same engine in their experiments. The tractor engine using Alkohl motor fuel developed 13.97 horsepower, 4.18 per cent higher than the rated power of 13.45.

Total and specific fuel consumption

The total fuel consumptions of all engines increased as the load increased. The total fuel consumption can not be used as a basis for comparison of fuel economy because of the differences in the load and in the size of the engines.

The specific fuel consumption or the amount consumed by the engines in pounds per brake-horsepower-hour is a more reliable basis for comparison. Charts 2 and 3 show the relative specific fuel consumption of all engines using different fuels. Except for the one-fourth load of the tractor, all engines required the least specific fuel consumption with kerosene. The 3 h.p., 6 h.p., and tractor engines had higher specific fuel consumption from one-half to full load with alcohol than with any of the other fuels.

The specific fuel consumption of the tractor engine at full load with Alkohl motor fuel was 1.250 pounds; with mixture A, 1.189 pounds; with mixture B, 0.973 pound; and with kerosene, 0.846 pound. The specific fuel consumption of the 3 h.p. and 6 h.p. engines decreased also in the same order. The 1-1/2 h.p. engine did not perform in the same manner, but its consumption of kerosene was still the lowest.

The lowest specific fuel consumption obtained in all the tests was 0.846 pound for kerosene, 0.973 pound for mixture B, and 1.189 pounds for mixture A. They were all obtained from the tractor engine. With commercial ethyl alcohol, the lowest consumption of 1.217 pounds was obtained from the 1-1/2 h.p. engine. The lowest consumption with Alkohl motor fuel was 1.250 pounds. It was obtained from the tractor engine.

Brake thermal efficiency

Charts 4 and 5 show the relative thermal efficiencies of all fuels at all loads. It will be noted that with the 1-1/2 h.p. and 3 h.p. engines, commercial ethyl alcohol gave higher efficiencies at full load than any other fuel. Mixture B came second. Kerosene gave the

[6] Cruz, S. R., and I. R. Ang. 1932. The use of alcohol as fuel for small gas engines. The Philippine Agriculturist 21: 613–627. *Charts 1–2.*

lowest efficiency with the 1-1/2 h. p. engine, whereas mixture A produced the lowest efficiency with the 3 h. p. engine.

Alkohl motor fuel gave the highest thermal efficiencies at full load with the 6 h. p. engine; mixture B, second. There were very light differences between the efficiencies of kerosene and mixture A. Mixture B gave a higher efficiency at full load than Alkohl motor fuel on the tractor engine. Mixture A gave the lowest efficiency.

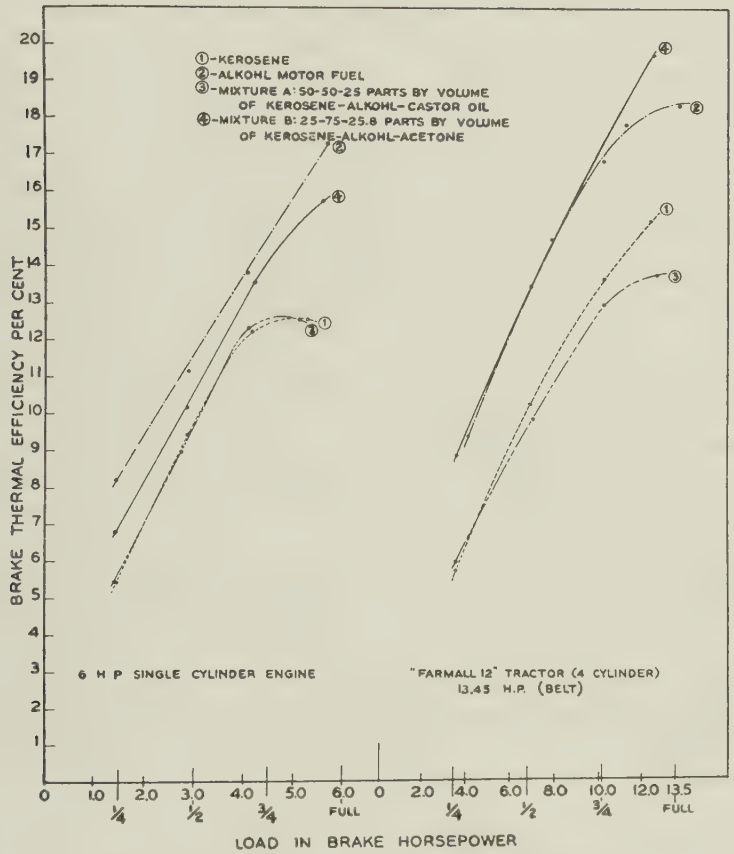
①-KEROSENE
②-ALKOHL MOTOR FUEL
③-MIXTURE A: 50-50-25 PARTS BY VOLUME OF KEROSENE-ALKOHL-CASTOR OIL
④-MIXTURE B: 25-75-25.8 PARTS BY VOLUME OF KEROSENE-ALKOHL-ACETONE
BRAKE THERMAL EFFICIENCY PER CENT
6 H P SINGLE CYLINDER ENGINE
"FARMALL 12" TRACTOR (4 CYLINDER) 13.45 H.P. (BELT)
LOAD IN BRAKE HORSEPOWER
FULL
FULL

Chart 5.—Showing relation between brake thermal efficiency and load in brake horsepower.

In general it may be noted that alcohol and those mixtures having a high percentage of alcohol in them gave higher thermal efficiencies than kerosene.

The highest brake thermal efficiency in all tests was 19.7 per cent, which was obtained from mixture B with the tractor engine at full

load. Commercial ethyl alcohol with 18.8 per cent at full load with the 1-1/2 h.p. engine was second highest. Alkohl motor fuel gave a maximum efficiency of 18.3 per cent with the tractor at full load. The highest figure obtained from kerosene was 15.2 per cent at full load of the tractor engine.

Relative specific fuel consumption

Table 3 shows the relative specific fuel consumption of all fuels used in all engines with kerosene as the basis for comparison. Based on the figures at full load with the 1-1/2 h. p. engine, the ratio by weight of commercial ethyl alcohol was 1.22; mixture A, 1.20; and mixture B, 1.40. With the 3 h.p. engine at the same load, the ratios were 1.51 with commercial ethyl alcohol, 1.44 with mixture A, and 1.40 with mixture B.

Based again upon the full load of the 6 h.p. engine, the ratio by weight of the fuels used was 1.28 with Alkohl fuel, 1.28 with mixture A, and 1.18 with mixture B. With the tractor engine, the ratio obtained was 1.48 with Alkohl motor fuel, 1.41 with mixture A, and 1.15 with mixture B.

The figures in the table show that only in one instance, that is, the tractor engine at one-fourth load with mixture B, did the ratio, by weight, fall slightly below 1, namely, 0.98. In general the specific fuel consumption with alcohol and mixtures containing a high percentage of alcohol with the same engine is greater than with kerosene.

The ratios by volume are also shown in table 3. They may be used in determining how much other fuels should cost in order to produce the same power cost as that of kerosene. For example, with kerosene at ₱0.11 per liter, Alkohl motor fuel with the tractor engine at full load should cost ₱0.045 per liter. This figure is obtained by dividing ₱0.11 by 1.32 which is the ratio of Alkohl motor fuel to kerosene.

SUMMARY AND CONCLUSIONS

From the results of the tests the following conclusions may be made:

1. Only straight commercial ethyl alcohol, Alkohl motor fuel, and mixture B were able to start cold engines.

2. The engines performed satisfactorily on all fuels after they had been sufficiently warmed up.

3. A knocking of the single cylinder engines with kerosene as fuel was discernible at three-fourths load and was more pronounced

as the load was increased to full. It was eliminated by water injection with the fuel.

4. A slight disturbance in the carburetor adjustment for a specific load with mixture A as fuel caused a sudden drop in the engine speed.

5. The exhaust gases of mixture A were characterized by an offensive odor. They were irritating to the eyes and throat.

6. The cooling water of all single cylinder engines boiled during the tests. The miximum temperature attained by the cooling water of the tractor was 82°C.

7. The maximum power attained by the 1-1/2 h.p., 3 h.p., and tractor engines exceeded the rated power of these machines. The 6 h.p. engine did not reach its rated power.

8. The 1-1/2 h.p. engine developed a maximum of 1.62 horsepower with mixture A, which was 8.00 per cent over the rated power. It developed 1.61 horsepower with ethyl alcohol.

9. The maximum power attained by the 3 h.p. engine was 3.46 horsepower with both mixtures A and B, which was 15.33 per cent higher than the rated power.

10. The tractor engine exceeded its rated power by 4.18 per cent with Alkohl motor fuel.

11. The lowest specific fuel consumption obtained in all tests was: 0.846 pound for kerosene, 0.973 pound for mixture B, 1.189 pounds for mixture A and 1.25 pounds for Alkohl motor fuel. They were all obtained from the tractor engine. With commercial ethyl alcohol, the lowest specific fuel consumption of 1.217 pounds was obtained from the 1-1/2 h.p. engine.

12. The highest brake thermal efficiency obtained was 19.7 per cent. It was produced by mixture B with the tractor engine at full load. Ethyl alcohol gave 18.8 per cent at full load with the 1-1/2 h.p. engine. Alkohl motor fuel with the tractor engine at full load produced 18.3 per cent. Kerosene produced a maximum of 15.2 per cent with the tractor engine at full load.

13. In general, alcohol and mixtures containing a high percentage of alcohol in them produced higher thermal efficiencies than kerosene.

14. Generally the specific fuel consumption of an engine with alcohol and mixtures containing a high percentage of alcohol is greater than with kerosene.

TABLE 1

Some of the physical properties and costs of the fuels used

FUEL	SPECIFIC GRAVITY	HEATING VALUES [a]	COST PER LITER
		B.t.u. per pound	*pesos*
Kerosene	0.801	19,876	0.11
Commercial ethyl alcohol (190° proof)	0.821	11,130	1.00
Alkohl motor fuel [b]	0.814	11,130	0.06
Mixture A [c] (with ethyl alcohol)	0.911	15,648	0.68
Mixture B [d] (with ethyl alcohol)	0.810	13,405	1.04
Mixture A [e] (with Alkohl motor fuel)	0.891	15,648	0.30
Mixture B [f] (with Alkohl motor fuel)	0.790	13,405	0.47

[a] Alcohol and kerosene from Teodoro's (1931) "Effects of variable compression ratio on the performance of tractor engine using alcohol." Castor oil from Lewkowitsch's (1904) "Chemical technology and analysis of oils, fats, and waxes." Acetone, computed.

[b] 100 parts by volume of commercial ethyl alcohol (190° proof) and 5 parts by volume of commercial gasoline.

[c] 50 parts by volume of kerosene, 50 parts of commercial ethyl alcohol, and 25 parts of castor oil. Castor oil cost ₱1.20 per liter.

[d] 25 parts by volume of kerosene, 75 parts of commercial ethyl alcohol, and 25.8 parts of acetone. Acetone cost ₱2.05 per liter.

[e] 50 parts by volume of kerosene, 50 parts of Alkohl motor fuel, and 25 parts of castor oil.

[f] 25 parts by volume of kerosene, 75 parts of Alkohl motor fuel, and 25.8 parts of acetone.

TABLE 2

Distillation results of all fuels used[a]

FUELS	SPECIFIC GRAVITY	INITIAL BOILING POINT	TEMPERATURE OF DISTILLATE AT CERTAIN DEFINITE VOLUMES IN CUBIC CENTIMETERS											END POINT	VOLUME IN CUBIC CENTIMETERS		
			5	10	20	30	40	50	60	70	80	90	95		Sudden rise of temperature at this volume	Distillate	Residue
		°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.			
Kerosene ..	0.801	147.6	171.2	178.1	185.5	192.0	196.5	203.5	206.5	214.3	219.9	230.3	240.4	247.0	——	96.7	1.5
Ethyl alcohol	0.821	77.3	77.5	78.1	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.3	78.3	89.3	98.2	98.9	0.3
Alkohl motor fuel	0.814	77.2	77.4	78.0	78.1	78.2	78.3	78.3	78.4	78.7	78.7	78.8	79.0	89.6	98.1	98.6	0.5
Mixture A (with ethyl alcohol) ..	0.911	74.3	77.7	78.3	78.5	79.0	80.7	169.0	176.2	180.5	192.1	217.2	225.2	231.2	48.8	97.7	1.3
Mixture B (with ethyl alcohol) ..	0.810	64.3	68.7	70.3	72.0	72.9	74.5	75.9	76.8	78.2	78.9	208.5	216.8	226.0	83.0	98.4	1.1
Mixture A (with Alkohl motor fuel)	0.891	74.2	78.0	78.2	78.4	79.0	80.9	169.2	177.2	181.4	193.7	219.5	226.9	233.2	48.9	97.3	1.3
Mixture B (with Alkohl motor fuel)	0.791	64.2	67.9	70.4	71.5	72.0	73.3	75.3	76.6	78.1	79.1	209.2	216.8	226.8	83.8	98.3	1.1

TABLE 3

Equivalent amount of fuels used in terms of kerosene per brake horsepower hour

ENGINE	LOAD	ALCOHOL [a]		MIXTURE A		MIXTURE B	
		Ratio of fuel used		Ratio of fuel used		Ratio of fuel used	
		By weight	By volume	By weight	By volume	By weight	By volume
1½ H.P. International	¼	1.49	1.54	1.27	1.12	1.28	1.27
	½	1.42	1.39	1.17	1.03	1.29	1.27
	¾	1.35	1.32	1.25	1.10	1.38	1.36
	Full	1.22	1.19	1.20	1.05	1.40	1.38
3 H.P. International	¼	1.45	1.42	1.24	1.09	1.16	1.15
	½	1.73	1.69	1.42	1.25	1.31	1.30
	¾	1.70	1.66	1.45	1.27	1.32	1.30
	Full	1.51	1.47	1.44	1.27	1.33	1.32
6 H.P. International	¼	1.18	1.05	1.28	1.15	1.19	1.21
	½	1.51	1.35	1.33	1.20	1.38	1.40
	¾	1.57	1.40	1.26	1.13	1.35	1.37
	Full	1.28	1.14	1.28	1.15	1.18	1.20
Tractor Farmall F 12	¼	1.09	0.97	1.22	1.10	0.98	0.99
	½	1.24	1.11	1.32	1.19	1.14	1.16
	¾	1.36	1.22	1.35	1.21	1.20	1.22
	Full	1.48	1.32	1.41	1.27	1.15	1.17

[a] Ethyl alcohol was used with the 1½ and 3 h.p. engines, and Alkohl motor fuel with the 6 h.p. and tractor engines.

COMPARATIVE STUDIES ON THE RATE OF GROWTH AND MATURITY OF BATTERY- AND RANGE-RAISED PULLETS [1]

PEDRO E. IGTANLOC

The practice of growing chicks in batteries was found effective in the United States and in other countries where their use simplifies the system of management and reduces the incidence of diseases and parasites. Whether or not the use of battery brooders will prove successful under Philippine conditions is still a matter of conjecture. Although some poultrymen have started to use them in this country, our present knowledge is still too inadequate to warrant definite conclusions.

A study to make comparisons of the rate of growth, maturity, and mortality of range-raised and battery-raised pullets was conducted, therefore, in the Poultry Division, Department of Animal Husbandry. It was started on February 15, 1936, and ended on April 30, 1937.

REVIEW OF LITERATURE

In a comparison of chicks and pullets raised in confinement and on the range, Kennard and Chamberlin (1934a) found that the rate of maturity was practically the same, but that the range lots were somewhat ahead in their production the second year. These authors found that the average weight of the pullets raised in confinement was considerably less in each of the four tests conducted. The mortality, however, although heavy in all the groups, was decidedly less among the caged birds.

In a subsequent work (1934b), the same authors reported the following results: in nine tests made, "the egg production was quite in favor of the layers on the range. The difference in the rate of mortality was less marked between the indoor or confined groups, which received the so-called complete rations, and those which had access to a good outdoor range." They further stated that, although the range method appeared advantageous for comparatively small flocks under farm conditions, this system would hardly prove practicable for large-scale commercial poultry enterprises.

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[1] Experiment Station contribution No. 1400. Prepared in the Department of Animal Husbandry under the direction of Associate Professor F. M. Fronda.

Fronda and Evangelista (1939) compared Los Baños Cantonese pullets and hens raised in batteries with those in laying pens. They found that the average egg production was higher among pullets raised in batteries than in laying pens. With hens, this condition was reversed; when the egg production of the hens and pullets in the batteries was combined and compared with that of the hens and pullets in the laying pens, however, no significant difference was noted.

Callenbach and Knandel (1935) reported that the layers in batteries consumed less feed than those in laying pens. They also observed that the mortality in the battery was significantly lower than that in the outdoor lot.

Kennard and Chamberlin (1939), in a study on the egg production and livability of pullets as affected by management, reported that the livability and total egg production of pullet layers in laying batteries was consistently better than that of similar pullets in floor pens. They further stated, however, that "in coping with a disease situation, portable colony houses on a well isolated range are the safest and most economical means for brooding chicks and raising pullets."

PLAN OF THE STUDY

Stock. Two hundred and twenty-three Los Baños Cantonese chicks artificially hatched from eggs produced by the College flocks were used in this study. Three sets of trials, each consisting of two lots, were conducted. The first had 85 chicks in each lot; the second, 68; and the third, 70.

Feeds. Both lots received the same ration composed of the following ingredients, parts by weight:

rice bran	56.25
ground corn	18.75
fish meal	25.00

To this ration the following supplements were added:

salt	2 per cent
cod liver oil	4 per cent
ground oyster shells	4 per cent

The average cost per kilogram of the feeds used was as follows:

rice bran	₱0.0482
ground corn	0.0503
fish meal	0.1609
salt	0.0164
cod liver oil	0.6100

The cost of one kilogram of the ration for the first twelve weeks of the experiment was ₱0.0925.

Battery brooder. The battery brooder used was obtained from M. H. Arndt and Company of New Jersey. This brooder was housed in the main building of the Poultry Division. It had four compartments, each divided in the middle. The uppermost compartment, measuring ninety by ninety centimeters, had a capacity for one hundred chicks. The lower compartments were the same in area as the uppermost. They were, however, provided with bigger feeding and watering troughs and the mesh of the wire floor was much bigger. The chicks were kept four weeks in the top compartment, three in the second, three in the third, and two weeks in the bottom. The uppermost compartment was provided with four 25-watt bulbs, two to each division, for heating purposes.

Brooder for the range lot. The chicks of the range lot were brooded in a portable fireless brooder made of wood with galvanized iron roofing and wire floor. This brooder, one and three-tenths by one meter in area, was placed in a grassy yard. Feed hoppers of bamboo and watering cans were provided. Fruit trees provided shade for the chicks.

Rearing house. After twelve weeks, the pullets of both lots were placed together in an "A" type rearing house, three and six-tenths by two and seven-tenths meters in area. The floor and droppings board were covered with lakeshore sand as a litter.

Feeding, care, and management. The same ration in the form of dry mash was given to both lots. The ingredients of the ration were mixed thoroughly; special care was taken to have the cod liver oil evenly mixed with the mash. In addition to the common ration, the battery lot was given grit and green feed in unlimited amounts. The grit was in the form of coarse sand, and the green feed consisted of finely chopped lawn grass.

In the battery brooder, the electric lights were maintained night and day from the first day of brooding to the third week. From thence, only one 25-watt bulb was left lighted until the fourth week. Fresh water was supplied twice a day. The feed was renewed daily and that which remained at the end of the week was weighed to obtain the consumption.

When the chicks were twelve weeks old, the cockerels were removed and the pullets of both lots were placed together in the rearing pen. They remained there up to the end of the experiment.

During this period, the pullets of both lots were given the College Standard rearing ration.

Records. The initial weights of the chicks in both lots and their weekly weights up to twenty-four weeks were taken. Records of mortality and amount of feed consumption were kept. Post mortem examinations, whenever possible, were made among the pullets. Other minor observations related to the study were made.

RESULTS AND DISCUSSION

Rate of growth

The mean weekly weights of the chicks up to twelve weeks are shown in table 1. The two lots began with about the same mean weights. At the age of three weeks the chicks in both lots had more than doubled their initial weights. It was after the fifth week that a difference in weight between the two lots became noticeable, the range chicks weighed slightly more than those raised in batteries. This advantage in weight increased up to twelve weeks. At this age, the battery lot chicks had a mean weight of 505.8 ± 8.42 grams; the range chicks, 534.5 ± 8.92 grams. Statistical treatment of the data presented in table 1 did not show a single case where the difference between the lots was significant although the difference in favor of the range lot chicks was consistent from the fourth week up to weaning age.

The mean weights of the pullets from the thirteenth to the twenty-fourth week are given in table 2. From this table we can see that the range pullets maintained their lead from the brooding period up to the end of the experiment. Again, as before, although this lead was consistently present in favor of the range pullets, statistical treatment of the data showed that they were insignificant.

Feed consumption and costs

The battery lot chicks consumed 245.63 kilograms of feed up to the weaning age; the range lot, 249.58 kilograms. The value of this feed, at ₱0.0925 a kilogram, was ₱22.72 for the battery lot and ₱23.09 for the range lot. The cost of the electric current used in the battery brooder was ₱8.82, a kilowatt hour costing ₱0.05. If we take the price of one kilogram liveweight of weanlings as ₱0.60, the value of the battery chicks was ₱43.40 and that of the range chicks, ₱44.25. From these data we find that the battery lot gave a return of ₱11.86 over the costs; the range lot, ₱21.16. The difference of ₱9.30 in favor

of the range lot was mainly due to the cost of the electric current used by the battery lot, all other items of cost being about the same for both lots. These results indicate that the use of the battery brooder under conditions of this experiment was not economical. On the other hand, the raising of chicks on the range offers some definite advantages over the use of battery brooders. The range provides an abundance of green feed, insect life, fresh air, sunshine, and exercise.

Maturity

The mean age at maturity of the pullets in the battery lot was 189.9 ± 1.59 days and that of the range lot was 184.9 ± 1.78. The average age of the earliest maturing bird in the battery lot was 151.0 ± 5.52 days and the average age of the latest maturing bird was 246.0 ± 3.09 days. Corresponding figures for the range lot were 146.7 ± 2.53 and 237.3 ± 2.76 days respectively. From these data, it may be seen that the range pullets matured a little earlier than the battery; the mean difference, however, was not significant. This result is in accord with that obtained by Kennard and Chamberlin (1934) who reported no significant differences in the age at maturity of range and confined pullets.

Mortality

The percentage mortality of the chicks in the two lots up to weaning age was as follows:

LOTS	NUMBER OF CHICKS	PERCENTAGE MORTALITY
Battery	223	35.9
Range	223	38.1

Difference = 2.2 per cent

Chi-square = 0.24

These results show that although the battery-raised chicks had less mortality than the range-raised chicks, still the difference was of no consequence, as shown by the chi-square test. In most cases the mortality in both lots was due to cold and roup. Some of the deaths in the range lot resulted from chicken pox. Eleven chicks of the battery lot died because of cannibalism.

The mortality of the pullets from weaning age up to the twenty-fourth week is summarized as follows:

LOTS	NUMBER OF PULLETS	PERCENTAGE MORTALITY
Battery	67	26.9
Range	63	11.1

Difference = 15.8 per cent
Chi-square = 5.19

It may be noted that a considerably higher mortality of significant value was obtained among the battery raised pullets than among those raised on the range. It is very probable that since the birds were confined in the battery during the first twelve weeks, they did not develop as much resistance as those that were raised outdoors. Thus, when they were turned out on the range, they were susceptible to diseases and the unfavorable conditions existing.

Of the pullets that died during this period, seven from the battery lot died because of the typhoon of December 3, 1936. The pullets had just been transferred to the rearing pens when the typhoon occurred. There were five pullets that died of the same cause in the range lot. Roup caused eleven deaths, nine in the battery lot and two in the range lot. The cause of the death of two pullets from the battery lot could not be ascertained.

Minor observations

It was observed that the battery weanlings were not so healthy in appearance as those raised on the range. At the end of the experiment, however, no appreciable difference as regards vigor and activity between the two lots could be noted. This would tend to show that the battery-raised pullets improved in condition after they had been placed on the range.

The appearance and growth of feathers was earlier and faster in the range lot. The battery chicks were not completely feathered at five weeks of age, while those raised on the range were quite feathered at this time.

As early as four weeks, the battery chicks were observed to pick the toes and vents of one another. This habit became serious as they grew older. A number of chicks died because of this. No such vice developed in the range raised chicks.

SUMMARY AND CONCLUSIONS

1. The chicks raised on the range were heavier at weaning age than those raised in the battery brooder. This advantage was carried over by the pullets up to the twenty-fourth week of age. The difference between the means, though consistent, was insignificant.

2. The two lots did not differ markedly in the amount of feed consumed.

3. The pullets of the range lot reached maturity a few days earlier than those of the battery lot.

4. The mortality of the range lot up to weaning age was insignificantly higher than that of the battery lot. From weaning age up to the twenty-fourth week the reverse was true; the mortality of the pullets from the battery lot was significantly higher than that of the range lot.

5. As a whole, it was found slightly more advantageous to raise chicks on the range than in the battery brooder.

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TABLE 1

Mean weekly weights of the chicks up to 12 weeks

AGE	BATTERY LOT		RANGE LOT	
	No. of chicks	Mean weight	No. of chicks	Mean weight
		grams		*grams*
1 day	223	27.6 ± 0.17	223	27.3 ± 0.18
1 week	200	36.7 ± 0.62	197	34.9 ± 0.54
2 weeks	180	48.7 ± 0.49	183	49.3 ± 0.92
3 "	165	66.3 ± 1.01	168	67.7 ± 1.13
4 "	156	87.9 ± 1.12	157	89.3 ± 2.01
5 "	149	125.7 ± 2.98	150	128.4 ± 3.65
6 "	146	157.1 ± 2.61	145	169.2 ± 3.57
7 "	143	205.8 ± 5.01	141	227.5 ± 5.47
8 "	143	262.3 ± 5.17	140	279.4 ± 4.31
9 "	143	326.2 ± 6.19	139	340.9 ± 5.12
10 "	143	386.2 ± 6.14	138	409.7 ± 7.98
11 "	143	448.4 ± 7.01	138	478.8 ± 8.25
12 "	143	505.8 ± 8.42	138	534.5 ± 8.92

TABLE 2

Mean weekly weights of the pullets from 13 to 24 weeks

AGE	BATTERY LOT		RANGE LOT	
	No. of pullets	Mean weight	No. of pullets	Mean weight
		grams		*grams*
13	67	483.5 ± 11.24	63	512.2 ± 11.85
14	60	542.7 ± 11.98	58	573.6 ± 12.23
15	57	612.4 ± 12.06	58	647.2 ± 12.52
16	54	673.2 ± 12.28	57	708.5 ± 13.78
17	51	725.5 ± 13.21	57	762.2 ± 12.07
18	50	789.7 ± 14.42	57	814.5 ± 13.24
19	49	816.2 ± 13.79	56	887.6 ± 14.25
20	49	922.5 ± 15.32	56	943.2 ± 15.71
21	49	995.7 ± 14.78	56	1008.4 ± 14.54
22	49	1051.4 ± 16.03	56	1067.3 ± 15.67
23	49	1095.7 ± 16.84	56	1108.6 ± 16.23
24	49	1145.5 ± 17.02	56	1159.2 ± 16.85

CULTURAL STUDIES OF ARROWROOT, EDIBLE CANNA, AND TURMERIC IN THE COLLEGE OF AGRICULTURE [1]

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The starch produced from arrowroot and edible canna is used for making biscuits and cakes. It is recommended for invalids and infants. Turmeric flour, which is prepared in the same way as cassava and arrowroot, is used for coloring material, in the preparation of curry powder, and in other condiments.

Review of literature

Arrowroot. Watt (1908), Woodrow (1910), and Nicholls (1929) have contributed some information on the effects of climate and certain cultural treatments upon arrowroot.

Edible canna. According to Nicholls (1929), edible canna is known as Queensland arrowroot in Queensland, Australia; "adeira" in Peru; and "tous-les-mois" in the West Indies. In Hawaii, the tops of the plants are used as forage for cattle and poultry.

MacMillan (1914) reported that in Queensland, the yield of edible canna varies from fifteen to twenty cwt. per acre (163.5 to 224.1 kgm. per hectare). The crop matures in six to eight months.

Chung and Ripperton (1924) said that the canna plant was introduced in Hawaii about the end of 1898 and afterwards distributed throughout the territory in order that the rhizomes might be used for food. Its maximum yield was obtained at an elevation of less than 1,500 feet (457.1 meters) where days and nights were relatively warm with adequate rainfall. At Glenwood Substation, Hawaii, seven tons per acre (17,297 kgm. per hectare) were produced within a nine-month growing season.

At Castner Substation, Hawaii, where manure was applied to the soil, twenty-eight tons of rhizomes per acre, or 69,188 kgm. per hectare, were obtained within twelve months. In twenty-four and

[1] Experiment Station contribution No. 1401. Most of the data in this paper were taken from theses presented for graduation by the junior authors with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1938, 1939, and 1940 respectively.

one-half months at Honolulu Station, the yield was forty-three tons of rhizomes per acre, or 106,253 kgm. per hectare.

Ripperton and Goff (1928) said that planting the rhizomes in furrows four inches (10.16 cm.) deep was the best method for Waimea district, Hawaii. Two seed pieces per hill, the best number, gave a yield of from 5.6 to 6.1 tons of rhizomes per acre, or 14,837.6 to 15,073.1 kgm. per hectare, within twenty months. They also found that the rootstocks that had been planted in furrows with a gradual hilling-up gave the highest yield and the largest and best preserved rootstocks, whereas those of the upraised beds were decidedly inferior.

These authors further stated that in Queensland, where growth is checked by cool weather and frosts during the winter, the crop is harvested ten months after planting.

Turmeric. Brown (1921) reported that, according to Krauch (1896), turmeric rhizomes contain two yellow dyes, one of which is soluble in water and the other, in alcohol. The water soluble dye (turmeric) is sensitive to both acids and alkalies and is, therefore, used as a chemical indicator. According to Brown, Krauch (1896) stated that turmeric is one of the best known of the natural dyes, that is, of those obtained from vegetative sources. It dyes silk, wool, and cotton a bright shade of yellow.

According to Stockdale (1925), turmeric can be grown in any kind of soil provided it is well drained. He said that seed pieces should be planted about three inches deep (7.6 cm.), one foot apart (30.48 cm.), and in rows one to one and one-half feet (45.72 cm.) apart. About 454.5 kgm. of seed pieces are required to plant an acre, or 1,122.4 kgm. per hectare. The crop matures in nine to ten months after planting. Stockdale further stated that the crop is ready to be harvested when the leaves and stems have withered and dried. A yield of about 6,819 kgm. of green rhizomes per acre, or about 16,839.7 kgm. per hectare, may be obtained.

Objects of the present work

The objects of the experiments were to study the agronomic characteristics and cultural requirements of arrowroot, edible canna, and turmeric, including the determination of: (*a*) age of the plant when rhizomes begin to form, (*b*) age at the beginning of flowering, (*c*) age at the maturing of the rhizomes, (*d*) actual yield of rhizomes, and (*e*) effect of planting in ridges and in furrows upon the yield of rhizomes.

Time and place of the study

The experiments were conducted from June, 1936, to June, 1938, covering a period of two years. The cultures were grown separately in the Experiment Station fields of the College of Agriculture.

MATERIALS AND METHODS

Planting materials

Rootstocks and suckers were used for arrowroot and edible canna, whereas rhizomes with at least two unbruised "eyes", or buds, were used as seed pieces for turmeric.

Land

The fields used in these experiments are portions of the upland experimental grounds of the Department of Agronomy. The soil is medium clay loam. According to Galvez (1936), the soil in these fields contains, on the average, 0.14 per cent nitrogen, 0.22 per cent phosphoric acid, 0.20 per cent potash, and 0.98 per cent lime.

Preparation of the land. The land was prepared in the same way as for corn, sugar cane, and other annual crops. It was plowed three times at intervals of seven days. Harrowing followed one to two days later. It was plowed first with a tractor-drawn plow and subsequently with a native animal-drawn one.

After the land had been thoroughly prepared, furrows ten to twelve cm. deep and one hundred cm. apart were laid out. For the ridge culture, beds about 30.5 cm. high and 45.5 cm. wide were made with the native plow.

Planting. Two methods of planting the seed pieces were used, namely, the ridge and the furrow method. In the ridge culture a rhizome of turmeric with two to three buds each was planted 5 centimeters deep and 80 centimeters apart on the ridges. In like manner suckers and rootstocks of arrowroot and edible canna were planted 5 centimeters deep and 80 centimeters apart in a slanting position on the ridges. Similarly, the rhizomes of turmeric and the suckers and rootstocks of arrowroot and edible canna were planted in the furrow.

The turmeric seed pieces were planted on June 20, 21, and 23, 1936; edible canna from June 29 to July 2, 1937; and arrowroot, on June 22, 1937.

Guard rows for the two cultural methods were provided for the determination of the age of the plant at formation and maturity of

rhizomes. The plants grown in the guard rows were given the same treatment as those in the experimental plots.

Arrangement of plots and replication of treatments. The plots for the two methods of culture were laid out alternately. Six replications for each cultural method were used in arrowroot and edible canna, whereas ten plots for each cultural method were used in turmeric.

Determination of the percentages of germination and stand. The percentages of germination of the different crops under the two cultural methods were based upon periodic counts of shoots that emerged from the soil in each plot.

Similarly, the percentage of stand in each plot in both cultural methods was determined by counting the number of hills with plants that reached maturity.

Determination of the age and height of the plants when rhizomes began to form. From time to time, several hills from the guard rows of each crop in both cultures were examined to determine the time when the rhizomes began to form. The height of 100 plants when the rhizomes began to form was determined by measuring from the surface of the ground to the tip of the tallest leaf.

Determination of height of the different crops at flowering and maturity. The height of 100 plants at the flowering stage was determined by measuring from the surface of the ground to the tip of the flower stalk. Likewise, the height of 100 plants at maturity was determined by measuring from the surface of the ground to the tallest leaf.

Care of the plants. The plants were cultivated with a five-tooth spike cultivator immediately after the rhizomes had germinated. The weeds between the hills in the rows were hoed. The plants in the ridge culture were hilled-up with a native plow in order to maintain the ridges, whereas those in the furrow culture were not hilled-up.

Harvesting. The plants were harvested when the flowers, leaves, and stems were thoroughly dry. Two methods of harvesting were used, namely, plowing with a Chattanoga plow and digging the hills one by one with a spading fork. These methods were tried to determine which of the two was faster.

RESULTS AND DISCUSSION

Field observations

Germination period. The germination of the different crops of the ridge and the furrow methods of culture occurred at about the same time. Shoots of arrowroot emerged from the soil in from seven to twenty-one days; edible canna, from nine to fourteen; and turmeric, from twelve to twenty-nine days after planting.

Development of arrowroot plants. Five to fourteen days after emergence from the soil, the arrowroot plants resembled young ginger plants. The leaves were thin, smooth, dark green, and pointed at the tip. Two months later, two to six suckers were produced at the base of the original plant. At the time the plants were about to flower, they produced small leaves, followed by a peduncle bearing small white flowers. As the plants approached maturity, the leaves and stems gradually changed in color from green to yellow and finally to brown. At maturity of the rhizomes, the whole plant dried out.

Development of edible canna. The young canna plants appeared like banana suckers with purple leaf-sheaths. The leaves of the full grown plants were light green and oblong in shape with a more or less rounded tip. The flowers, in pairs, were dark red and had narrow petals. The spikes were twenty-five to thirty cm. long or about one-sixth of the length of the stalk that bore them. As the rhizomes matured, the leaves changed from light green to yellowish brown, starting from the margin; finally the whole vegetative part of the plant dried out. The mother rhizomes decayed after producing daughter rhizomes. Each daughter rhizome gave rise to one or two plants, and as more plants developed, more rhizomes were produced. In each hill, sixteen to twenty-two rhizomes were obtained.

Development of turmeric. Turmeric plants appeared like corn seedlings when they were from one to two weeks old. As they grew older, the leaves became broad, thin, smooth, pale green, and slightly pointed at the tip. The flower stalk of the plant was borne within the tuft of the leaves. The spike, twelve to twenty cm. long, was about the same in length as the stalk that bore it. At the top of the mother stock, primary rhizomes were produced. These produced branches, some of which produced crowns. The daughter rhizome did not send out crowns. More than one mother rhizome was found in a hill. By the time the rhizomes reached maturity, the leaves and stems were completely dry. This was used as the index of maturity of the rhizomes.

Pests and diseases. Although arrowroot and edible canna were practically free from insect pests, turmeric was attacked by *Dichocrosis* sp.,[2] an insect of the family Pyralidae. This particular insect attacked the heart of the stem of the plant before the flowers appeared and continued until after the flowering period.

Arrowroot and turmeric were free from diseases, whereas rhizomes of edible canna were attacked by bacterial rot. The disease, however, did not materially damage the crop.

Germination and stand. In all cases, as shown in table 1, the differences between the percentages of germination and stand of the crops in the ridge and furrow cultures were insignificant. This seems to indicate that germination and stand of the crops were not affected materially by the cultural methods used.

Age and height of plants at different stages of growth. The age of the different crops when rhizomes began to form, as shown in table 2, indicates that cultivation of arrowroot, edible canna, and turmeric should cease about 97, 79, and 65 days, respectively, after planting, as the rhizomes being formed at these times may be destroyed if this is done later.

Comparative yield of rhizomes under the ridge and furrow cultures

The production under the ridge and furrow cultures of the three crops studied are presented in table 3. The average yield per plot of arrowroot was 80.93 ± 13.85 kgm. of rhizomes in the ridge and 58.53 ± 3.95 kgm. in the furrow cultures. The computed yield per hectare was 2,140.70 ± 249.50 kgm. in the ridge and 1,548.20 ± 115.60 kgm. in the furrow. Although the production of the ridge culture was greater per hectare than that of the furrow, the difference of 592.48 ± 275.00 kgm. was insignificant.

The average production per plot of edible canna in the ridge culture was 149.80 ± 2.30 kgm. of rhizomes, whereas in the furrow it was 190.85 ± 3.53 kgm. The computed yield per hectare of this crop was 4,992.90 ± 77.50 kgm. in the ridge and 6,362.90 ± 115.60 kgm. in the furrow culture. The difference in yield of the plants under the furrow and ridge cultures of 1,370.00 ± 139.20 kgm. per hectare was highly significant. This may be explained by the nature of rhizome production of the plant. The rhizomes are produced just below the surface of the soil and spread horizontally so

[2] Identified in the Department of Entomology, College of Agriculture.

that if they are planted on ridges, the space for the growth of the rhizomes is somewhat smaller than when they are planted in furrows. This result corroborates the findings of Ripperton and Goff (1928), who reported that the rootstocks planted in furrows at a depth of four inches with gradual hilling-up gave the highest yield and the largest and best preserved rootstocks, whereas those of the upraised beds were decidedly inferior.

The average yield per plot of turmeric was 174.04 ± 7.70 kgm. of rhizome under the ridge and 173.22 ± 6.77 kgm. under the furrow culture. When computed per hectare, the ridge culture produced 4,297.50 ± 192.80 kgm., and the furrow, 4,278.20 ± 157.40 kgm. of rhizomes, with an insignificant difference of 19.30 ± 248.00 kgm. per hectare.

The data on rhizome production of the different crops in this experiment indicate that arrowroot and turmeric can be grown either on ridges or in furrows, whereas edible canna should be grown in furrows.

SUMMARY AND CONCLUSIONS

1. Germination of arrowroot, edible canna, and turmeric under the ridge and furrow methods occurred at about the same time. Shoots of arrowroot emerged from the soil as early as seven to twenty-one days; edible canna, nine to fourteen days; turmeric, twelve to twenty-nine days after planting.

2. The percentages of germination and the stand of the crops under the two cultural methods did not differ significantly.

3. Formation of rhizomes of each crop under the ridge and furrow cultures began practically at the same time, i.e., arrowroot, ninety-seven days; edible canna, seventy-nine days; and turmeric, sixty-five days after planting.

4. The differences in height of the plants under the ridge and furrow cultures at different stages of growth were all insignificant except in two cases. Edible canna plants in the furrow were significantly taller than those in the ridge at flowering, and turmeric plants in the ridge were significantly taller than those in the furrow culture when the rhizomes began to form.

5. Arrowroot flowered in 196 days, edible canna in 123 days, and turmeric in 155 days after planting. Arrowroot matured in 276 days, edible canna in 324 days, and turmeric in 236 days after planting.

6. For rhizome production, arrowroot and turmeric may be grown either by the ridge or furrow method, whereas edible canna should be grown in furrows.

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TABLE 1

Percentages of germination and stand of arrowroot, edible canna, and turmeric

CROPS	AVERAGE PERCENTAGE OF GERMINATION			AVERAGE PERCENTAGE OF STAND		
	Ridge culture	Furrow culture	Difference	Ridge culture	Furrow culture	Difference
Arrowroot	98.60 ± 0.21	98.30 ± 0.21	0.30 ± 0.29	96.70 ± 0.20	97.20 ± 0.26	0.50 ± 0.33
Edible canna	96.50 ± 0.50	95.90 ± 0.30	0.60 ± 0.60	95.50 ± 0.30	95.10 ± 0.50	0.40 ± 0.60
Turmeric	92.60 ± 1.10	91.50 ± 1.09	1.10 ± 1.54	92.40 ± 1.09	91.20 ± 1.17	1.20 ± 0.97

IMPERIAL BUREAU OF PASTURES & FORAGE CROPS
HURLEY, BERKSHIRE, GREAT BRITAIN
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TABLE 2

Age and average height of arrowroot, edible canna and turmeric at different stages of growth

STAGES OF GROWTH	ARROWROOT			
	Age	Height of plants		
		Ridge culture	Furrow culture	Difference
	days	*cm.*	*cm.*	*cm.*
Age and average height of plants when rhizome began to form	97	25.02 ± 0.12	25.00 ± 0.12	0.02 ± 0.16
Age and average height of plants at flowering	196	41.01 ± 0.03	41.14 ± 0.26	0.13 ± 0.26
Age and average height of plants at maturity	276	41.63 ± 0.17	42.11 ± 0.87	0.48 ± 0.89

TABLE 2 (continued)

STAGES OF GROWTH	EDIBLE CANNA			
	Age	Height of plants		
		Ridge culture	Furrow culture	Difference
	days	*cm.*	*cm.*	*cm.*
Age and average height of plants when rhizome began to form	79	56.90 ± 0.40	57.80 ± 0.40	0.80 ± 0.50
Age and average height of plants at flowering	123	174.30 ± 0.60	179.00 ± 0.30	4.70 ± 0.80
Age and average height of plants at maturity	324	73.30 ± 0.90	74.30 ± 0.50	1.00 ± 1.00

TABLE 2 (continued)

STAGES OF GROWTH	TURMERIC			
	Age	Height of plants		
		Ridge culture	Furrow culture	Difference
	days	*cm.*	*cm.*	*cm.*
Age and average height of plants when rhizome began to form	65	36.68 ± 0.76	31.40 ± 0.67	5.28 ± 1.02
Age and average height of plants at flowering	155	71.88 ± 0.83	72.52 ± 0.76	0.64 ± 1.27
Age and average height of plants at maturity	236	82.72 ± 0.58	80.04 ± 0.76	2.68 ± 0.91

TABLE 3

Average yield of rhizomes per plot and per hectare of arrowroot, edible canna, and turmeric in the ridge and furrow cultures

CROPS	AREA OF PLOT	RIDGE CULTURE		FURROW CULTURE		DIFFERENCE IN YIELD PER HECTARE	VALUE OF DIFFERENCE
		Yield per plot	Computed yield per hectare	Yield per plot	Yield per hectare		
	sq. m.	*kgm.*	*kgm.*	*kgm.*	*kgm*	*kgm.*	
Arrowroot	368	80.93±13.85	2,140.70±249.50	58.53±3.95	1,548.20±115.60	592.50±275.00	Insignificant
Edible canna .	300	149.80± 2.30	4,992.90± 77.50	190.85±3.53	6,362.90±115.60	1,370.00±139.20	Significant
Turmeric	405	174.04± 7.70	4,297.50±192.80	173.22±6.77	4,278.20±157.40	19.30±248.00	Insignificant

A COMPARATIVE STUDY OF GAPLEK MEAL AND CORN AS BASAL FEED FOR GROWING AND FATTENING PIGS[1]

PEDRO M. ASICO

The object of this study was to compare the feeding value of gaplek meal[2] with corn for growing and fattening pigs.

The experiment was conducted from January 7 to August 5, 1934, in the Department of Animal Husbandry.

Materials

Weanling pigs. Fourteen Berkjala weanling pigs about ten weeks old at the beginning of the experiment were used. They were fairly uniform in size and condition.

Feeds used. The feeds used and price of each at the time of the experiment were as follows:

Rice bran	3.00	centavos	a	kgm.
Corn	4.18	"	"	"
Gaplek (Ganay, 1933)[3] ...	10.76	"	"	"
Copra meal	2.57	"	"	"
Shrimps	14.27	"	"	"
Mineral mixture	3.10	"	"	"

Methods

Allotment of pigs. The pigs used in this experiment were divided into two lots consisting of seven pigs to each lot. Care was taken that the two lots should be as uniform as possible in sex, size, and condition. The control or corn lot was designated as lot I and the cassava lot, as lot II.

Ration mixture used. The ration mixtures used in the different periods of the experiment were as follows:

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[1] Experiment Station contribution, No. 1402. Prepared in the Department of Animal Husbandry under the direction of Assistant Professor Mariano Mondoñedo.

[2] Gaplek—sliced and dried cassava roots.

[3] GANAY, MARCELINO A. A preliminary study of gaplek or dried peeled roots of cassava, its preparation, storage, and cost of production. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. 1933. Unpublished.)

Ration for the first 70-day period

FEEDS	LOT I	LOT II
Corn	15 parts	0 parts
Gaplek meal	0 "	15 "
Rice bran	60 "	60 "
Copra meal	20 "	20 "
Shrimps	5 "	5 "
Total	100 parts	100 parts

Ration for the second 70-day period

FEEDS	LOT I	LOT II
Corn	20 parts	0 parts
Gaplek meal	0 "	20 "
Rice bran	60 "	60 "
Copra meal	17 "	17 "
Shrimps	3 "	3 "
Total	100 parts	100 parts

Ration for the third 70-day period

FEEDS	LOT I	LOT II
Corn	25 parts	0 parts
Gaplek meal	0 "	25 "
Rice bran	60 "	60 "
Copra meal	14 "	14 "
Shrimps	1 "	1 "
Total	100 parts	100 parts

Mineral mixture used. The mineral mixture used consisted of 45 parts common salt, 45 parts corncob charcoal, and 10 parts slaked lime. To every 100 kilograms of the feed mixture used, 2 kilograms of the mineral mixture were added.

Source of gaplek used. The gaplek used in this experiment was obtained from the Department of Agronomy. The method of preparation is described by Mendiola (1931) and the chemical analysis given by Adriano, Ramos, and Ynalvez (1932).

Preparation of ration. The gaplek used in this experiment was ground to about the coarseness of standard rice bran. A stock feed mixture for each lot was prepared to last the pigs for one week.

Feeding. The pigs of both lots were hand-fed twice daily, the morning feed being given between 6:00-7:00 a. m. and the evening feed between 4:00-5:00 p. m. The feed was given to the pigs in the form of fairly thick slop. Water was added just before feeding. The animals were given as much feed as they would readily consume.

Duration of the experiment. The feeding trial was conducted for 210 days divided into three 70-day periods. No reallotment of the pigs was made as the experiment continued from one period to another.

Weighing. Every week the pigs were weighed individually between 3:00-4:00 p.m. before they received their evening feed and after they had been washed and allowed to dry.

MANAGEMENT

First 70-day period

Except for the difference in the ration, the pigs were given the same treatment throughout. During the whole period they were driven into a good growth of camote pasture after each feeding. They were given a bath before every feeding. At feeding time they were driven to the hog house where each lot was fed in a separate pen. At noon they were driven into the hog house for watering, then driven back to the pasture. They were trained to go into their respective pens at feeding time.

Second 70-day period

At the close of the first period, March 18, 1934, the pasture was almost depleted of camote vines. The animals were then transferred to a paddock bare of vegetation near the hog house. They were treated in the same manner as in the first 70-day period, except that, instead of being turned loose in the pasture, they were supplied with camote soilage at the rate of one per cent of their total live weight taken weekly. During inclement weather, however, they were kept in the hog house over-night and in some cases during a large part of the day.

Third 70-day period

During the third 70-day period, the pigs were kept in the same lot. Practically the same kind of care and management was given to them during this period as in the second 70-day period.

RESULTS

A summary of the results obtained during the partial and whole feeding test follows:

First 70-day period

	LOT I	LOT II
Average initial weight per pig	12.71 kgm.	12.71 kgm.
Average daily gain in weight per pig	0.26 "	0.25 "
Feed consumed per kgm. gain	3.43 "	3.51 "
Feed cost per kgm. gain	₱0.13	₱0.17

Second 70-day period

Average initial weight per pig	30.63 kgm.	30.23 kgm.
Average daily gain in weight per pig	0.33 "	0.28 "

	LOT I	LOT II
Feed consumed per kgm. gain	5.33 "	6.35 "
Feed cost per kgm. gain	₱0.19	₱0.31
Third 70-day period		
Average initial weight per pig	53.80 kgm.	49.69 kgm.
Average daily gain in weight per pig	0.31 "	0.30 "
Feed consumed per kgm. gain	7.11 "	6.86 "
Feed cost per kgm. gain	₱0.24	₱0.35
Combined 210-day period		
Average initial weight per pig	17.71 kgm.	12.71 kgm.
Average final weight per pig	75.29 "	70.49 "
Average daily gain in weight per pig	0.30 "	0.27 "
Feed consumed per kgm. gain	5.39 "	5.68 "
Feed cost per kgm. gain	₱0.19	₱0.28

DISCUSSION OF RESULTS

First 70-day period

It may be seen in the summary of results that lot I (full fed on the standard ration) made an average daily gain per pig of 0.26 kgm.; lot II (full fed on gaplek), 0.25 kgm. If the difference is expressed in percentage and lot I taken as 100 per cent, lot II was 96.0 per cent as efficient as lot I. This difference may be considered negligible.

From the point of view of the amount of feed required to make a kilogram gain in weight, lot I needed 3.43 kgm. feed, lot II, 3.51 kgm. The gaplek ration, therefore, was 98.0 per cent as efficient as the corn ration.

The cost of feed based on the current prices at the time of the experiment required to make a kilogram gain in live weight was 13.0 centavos for lot I and 17.0 centavos for lot II, making lot I cheaper than lot II by 4.0 centavos.

Second 70-day period

During the second 70-day period, the pigs on corn ration made an average daily gain per pig of 0.33 kgm.; those on the gaplek ration, 0.28 kgm.; thus lot I made 18 per cent more gain than lot II.

To make a kilogram gain in live weight, lot I required 5.33 kgm. of feed; lot II, 6.35 kgm. In other words, lot II was only 85 per cent as efficient as lot I. As in the first 70-day period, lot I required less feed to make a kilogram gain than lot II.

If the computations are based on the current prices of feed at the time of the feeding test, lot I consumed 19.0 centavos and lot II,

31.0 centavos worth of feed to make a kilogram gain in live weight. Lot I was ₱0.12 less than lot II.

Third 70-day period

Lot I continued to excel lot II in rapidity of gain. It made an average daily gain per pig of 0.31 kgm., while lot II made 0.30 kgm. Taking lot I as 100 per cent, lot II was 97 per cent as efficient. The results obtained showed very little difference in the efficiency of the two feeds under comparison.

In feed consumption, lot I required 7.11 kgm. and lot II, 6.86 kgm. feed to make a kilogram gain. Expressed in percentage the gaplek ration was 4 per cent more efficient than the standard ration.

As to feed cost per given unit gain, lot I required 24.0 centavos and lot II, 35.0 centavos worth of feed to make a kilogram gain in weight. It can be noted that though lot I required more feed to make a kilogram gain in live weight than lot II, the cost of the feed in lot II was higher than in lot I by 10.3 centavos.

Combined 210-day period

From the results of the combined 210-day feeding trial, it may be seen that lot I made more rapid and economical gain than lot II, though no marked difference exists. Lot I made an average daily gain per pig of 0.30 kgm. and lot II, 0.27 kgm. According to these results, cassava meal was only 90 per cent as efficient as corn. The average amount of feed required for a kilogram gain was 5.39 kgm. for lot I and 5.68 kgm. for lot II. Lot II, therefore, was only 95 per cent as efficient as lot I.

In terms of cost of feed to make a kilogram gain in live weight, however, lot I required 19.0 centavos and lot II, 28.0 centavos. It may be noted that the cost per kilogram of the feed mixture of lot II is very much higher than that of lot I. This is because the average cost of gaplek used in this experiment was 10.76 centavos per kilogram (Ganay, 1933).[4] Mendiola (1931) states that gaplek imported from Java is ordinarily sold at ₱30 to ₱40 a ton or ₱0.03 to ₱0.04 a kgm. At this price the cost of the feed mixture for lot II in this experiment would be greatly reduced.

Based, however, on the salable gain in weight of the pigs at the end of the 210-day period, lot I made a total gain of 438 kgm.; lot II, 404.4 kgm. To make these gains, lot I required 2365 kgm. and lot II, 2295 kgm. of feed. The cost of the feed consumed by lot I

[4] Footnote 3.

was ₱83.282; lot II, ₱112.972. Thus the cost of feed to make a kilogram gain in live weight for lot I was ₱0.19 and for lot II, ₱0.28.

In the summary of results, it may be noted that the efficiency of cassava meal decreased in the second 70-day period but picked up during the third 70-day period. Thus, in the rate of gain the cassava meal was 96 per cent as efficient as corn in the first 70-day period, 85 per cent in the second, and 97 per cent in the third. Based on the amount of feed required to make a kilogram gain in live weight, cassava meal was 98 per cent as efficient as corn in the first feeding period of the experiment, 84 per cent in the second and 104 per cent in the third. The average for the whole 210-day feeding trial from the point of view of rapidity of gain was 90 per cent for lot II, and of feed consumed per unit of gain, 95 per cent.

SUMMARY AND CONCLUSIONS

1. With the amount of feed required for a given unit of gain taken as the basis for comparison, gaplek meal under the conditions of this experiment was 96 per cent as efficient as corn for pigs 10 to 20 weeks old (first 70-day period of the feeding trial); 85 per cent for pigs 20 to 30 weeks old (second 70-day period); and 97 per cent for pigs 30 to 40 weeks old (third 70-day period). The average feeding efficiency of cassava meal for the 210-day feeding trial was 90 per cent.

2. With calculations based on the amount of feed consumed to make a kilogram gain, gaplek meal was 98 per cent as efficient as corn in the first 70-day period of the experiment, 84 per cent in the second, and 104 per cent in the third. The average efficiency of the cassava meal for the whole 210-day feeding trial was 95 per cent as efficient as corn.

3. With calculations based on the cost of feed per kilogram gain, lot II required 17.0 centavos in the first 70-day period of the experiment, 31.0 centavos in the second, and 34.6 centavos in the third. In the combined 210-day feeding trial, lot I required an average of 19.0 centavos and lot II, 28.0 centavos worth of feed to make a kilogram gain in live weight. The high cost of production of gaplek used in the experiment largely accounts for the higher cost of the feed mixture for lot II.

4. Gaplek meal is a good substitute for corn in the ration for growing and fattening pigs, if the price of gaplek is 95 per cent that of corn.

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A STUDY OF "SINGLE VALUE" PROPERTIES OF SOILS: MAXIMUM WATER-HOLDING CAPACITY AND SHRINKAGE [1]

Luis D. Fadullon

The "single value" properties of a number of Philippine soils were studied. The work dealt with seven different single values: namely, apparent specific gravity, real specific gravity, maximum water-holding capacity, pore space, volume expansion, soil shrinkage, and moisture content in the air-dry state. All of these properties affect important characteristics exhibited by soils and cause outward phenomena and effects in soils.

Investigations made of different "single value" constants probably originated in England and in the West Indies. Keen and Coutts (1928), Coutts (1929), Hardy (1923), Haines (1923), Hardy (1925), Keen and Raczkowski (1921), Coutts (1930), and many other British and West Indian soil technologists have worked on single value property determinations. To these investigators, "single value" soil properties serve to distinguish certain soil characteristics by means of a single number instead of by a group of figures such as those obtained from a detailed mechanical analysis. Single value property determinations are simple and easy to carry out because most of them do not need special or elaborate apparatus.

The "single value" constants are important in future studies of soils and soils men like them. In fact "single value" studies are now employed in soil physics, because work along these lines has shown results which are very reliable.

MATERIALS AND METHODS

Materials. The soils used in this study were collected from the Experiment Station of the College of Agriculture, University of the Philippines, from various places in the Maquiling area, and from the Davao Penal Colony.

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[1] Experiment Station contribution No. 1403. Prepared in the Department of Soils under the direction of Dr. Robert L. Pendleton, formerly head of the Department.

Preparation of soil samples. The soil collected from the Experiment Station of the College of Agriculture was air-dried for many weeks.

The major portion of the samples used were stock samples. They were kept in covered quart mason jars and were well air-dried. The soil samples were ground and then sieved through a 100-mesh sieve. The unsieved portion was passed through a 1-mm. sieve. These sieved soils of two sizes were then mixed thoroughly for use in the experiments. The two sievings were done in order to break up the compound particles and to prevent the formation of varying amounts of soil crumbs, which would affect the packing of the soils in the boxes.

Methods. The methods suggested by Keen and Raczkowski (1921) were followed in the determination of maximum water-holding capacity, apparent specific gravity, real specific gravity, pore space, and volume expansion of soils. The Keen-Raczkowski boxes were used in these determinations.

The weighing data for the different determinations were as follows:

(a) — Wt. of brass box, and filter paper
(b) — Wt. of brass box and saturated filter paper
(c) — (b) + air-dry soil sample
(d) — (b) + saturated soil sample
(e) — (b) + saturated residual soil sample
(f) — (a) + oven-dry residual sample
(g) — Wt. of watch glass alone.
(h) — (g) + saturated surplus soil
(i) — (g) + oven-dry surplus soil
V — Internal volume of brass box

From the above and the measured internal volume of the box in cc., the following values were computed:

(c-b) — Wt. of air-dry soil sample put in the box
(b-a) — Amount of water in saturated filter paper
(d-b) — Wt. of saturated soil in the box
(e-b) — Wt. of saturated residual soil
(f-a) — Wt. of oven-dry residual soil
(c-f) + (b-a) — Amount of water taken up by the sample
(e-b) — (f-a) —Amount of water taken up by the sample
(V) — (e-f) + (b-a) — Volume of residual soil
(h-i) + (i-g) — Volume of water in saturated surplus soil + volume of the surplus soil.

The series of computations for the main soil properties were as follows:

$$\frac{(c\text{-}b)}{V} = \text{Wt. of 1 cc. of soil (apparent sp. gr.)}$$

$$\frac{(d\text{-}b) - (c\text{-}b)}{(c\text{-}b)} = \text{Amount of water taken up by 1 gm. soil}$$

$$\frac{(e\text{-}b) - (f\text{-}a)}{V} = \text{Pore space of soil}$$

$$\frac{(f\text{-}a)}{V - (c\text{-}f) + (b\text{-}a)} = \text{Specific gravity of soil}$$

$$\frac{(h\text{-}i) + \frac{i\text{-}g}{sp.\ gr.}}{V} = \text{Volume expansion of 1 cc. soil}$$

Determination of the shrinkage of soils. With a burette, sufficient distilled water was added little by little to ten or fifteen grams of soil until the soil was almost sticky. The soil and water were mixed with a spatula. A portion of the mass was taken and further kneaded by hand to remove air bubbles. The kneaded sample was immediately molded into a conical shape, and the measurements were taken at once.

The technique of measurement consisted of obtaining the volume of the moist conical block just after formation and again after the block had been oven-dried at 100°C. for 24 hours. The volume measurements were made by determining the amount of mercury displaced in a constant-volume bottle.

Determination of the moisture content in the dry state. Crucibles were first heated in an electric oven, cooled in desiccators, and weighed in an analytical balance. A portion of each soil sample was weighed in these crucibles, then dried in the electric oven at 100°C. to 105°C. to constant weight. The weights of samples determined in two stages gave the differential weights equivalent to the amount of moisture the samples contained in their dry state.

Determination of the different relationships. The relationships of the different soil properties determined were observed from the results shown in table 2. Table 1 shows the soil samples used in this study with their numbers, type names, and origin. The tabulated results of various determinations are on file in the Department of Soils, College of Agriculture.

RESULTS AND DISCUSSION

The water absorbed and retained by the soils in the Keen-Raczkowski perforated boxes showed characteristic values for different

soil types. Established ranges were obtained for six kinds of soils together with other soil constants (table 3).

The maximum water-holding capacity is related to pore-space (table 2). The soil shrinkage shows ascending and descending values following, in general, the trend of rise and fall of the water-retentive capacities of soils. This behavior was shown by samples Nos. 3, 8, 52, and 63. This discrepancy can hardly be due to experimental error; at least no apparent cause for mistake could be traced in the procedure for its determination. The above discordant result, however, might be interpreted by assuming that the samples referred to possessed a higher organic matter or colloidal content which imbibed more water without materially affecting the pore space.

The volume expansion figures were significantly much lower than the volume shrinkage. It should be noted that the shrinkage coefficient was determined on well-kneaded samples while that of volume expansion was obtained from a well compacted but not puddled mass. Whereas in the shrinkage determination, the kneaded conical soil block was quite free to shrink, the soil mass which was allowed to swell was free to do so only in one direction—upward. It may also be noted that while the two properties differ greatly in value, it is apparent that they are related to each other.

In the same manner the hygroscopic moisture or the moisture content in the air-dry state of the samples is correlated with the shrinkage. In a considerable number of cases, an increase of hygroscopic water accompanied an increase of the shrinkage coefficient.

Significance of some "single value" properties of soils studied in their relation to agriculture. In general, it is believed by Haines (1925) that the particular problem of shrinkage in soils is particularly important in certain tropical clays where the wide cracks which develop in some soils in dry weather seriously injure the root systems of the crops and depress yields. In the present study extensive shrinkage is clearly shown in a number of Philippine soils. The Calumpang loam, for instance, and the heavy soils from Davao exhibited shrinkage coefficients as high as 118.1 and 116.25 per cent respectively; this would seem to indicate that soils of such types would crack readily and seriously. These soils are not suited to crops other than lowland rice. The tendency of soils to shrink is also indicated by the water-holding capacity measured in the Keen-Raczkowski method; a high water-holding capacity indicates a tendency to shrink greatly. The relationship is directly proportional. The

importance of soil shrinkage and expansion is that it is a leading factor in soil granulation in the loosening and development of a crumb or granular structure.

In all soils studied, variations were found in all of the seven soil constants determined. It is, therefore, important to consider the relations between these various single values and cultivation, the most basic operation in agriculture. This was stressed by Haines (1925) in the study of the mechanical properties of soils concerned in cultivation. Although this study dealt mainly with soil resistance as related to plowing, it may be also considered in connection with the seven properties discussed in this paper. The heaviness or resistance of soils is related to the above soil constants. Therefore, although these values may not have been actually studied, it may be expected that the present determinations have some significant bearing in the designing of the plow.

SUMMARY AND CONCLUSIONS

(1) With the exception of the apparent and real specific gravities in different types of soil as well as in the same soil types, the single values determined varied considerably.

(2) Different kinds of soils were found to possess different ranges of variations for each of the seven single values shown in table 3.

(3) The Calumpang clay loam exhibited the highest values for each of the seven single values.

(4) The pore space, though usually greater in value than the maximum water-holding capacity, was significantly lower in a few cases.

(5) The maximum water-holding capacity was found to be directly proportional to the pore space.

(6) A moderate correlation existed between maximum soil shrinkage and water-holding capacity, volume expansion, and moisture content in the air-dry state.

(7) The significance of seven "single value" properties of soils studied has been discussed in relation to agriculture as well as to the physical characteristics of soils.

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TABLE 1

Original soil samples used with their numbers, type names, and origin

Sample No.	Original stock number	Soil types	Depth	Origin	
				Locality	Province
			cm.		
1	31–1	Lipa light silty clay	0–25	Alaminos	Laguna
2	26–1	Lipa clay loam	0–25	Alaminos	Laguna
3	30–2	Lipa clay loam	20–25	Alaminos	Laguna
4	31–1	Lipa light silty clay loam	0–25	Alaminos	Laguna
5	33–1	Lipa light silty clay loam	0–25	Alaminos	Laguna
6	29–1	Lipa light silty clay loam	0–25	Alaminos	Laguna
7	32–3	Calumpang clay loam	50–60	Alaminos	Laguna
8	28–2	Lipa clay loam	0–25	Alaminos	Laguna
9	46–2	Calumpang clay loam	35–55	Calauan	Laguna
10	4–1	Macolod clay loam	0–15	Calauan	Laguna
11	11–1	Calumpang clay loam	0–25	Calauan	Laguna
12	37–1	Lipa light silty clay loam	0–25	Calauan	Laguna
13	10–2	Calumpang loam	30–65	Calauan	Laguna
14	16-1	Calumpang loam	0–25	Mamatid	Laguna
15	12—2	Calumpang loam	40–60	Mamatid	Laguna
16	15–1	Calumpang silt loam	0–25	Mamatid	Laguna
17	30–50	Calumpang silty clay loam	30–50	Mamatid	Laguna
18	17–1	Lipa clay loam	0–25	Mamatid	Laguna

TABLE 1 (continued)

Sample No.	Original stock number	Soil types	Depth	Origin	
				Locality	Province
			cm.		
19	5–1	Calumpang loam	0–25	Nanhaya	Laguna
20	9–2	Calumpang clay loam	30–50	Nanhaya	Laguna
21	5–2	Calumpang clay	30–75	Nanhaya	Laguna
22	7–1	Calumpang clay	0–25	Nanhaya	Laguna
23	8–1	Lipa light silty clay loam	0–25	Nanhaya	Laguna
24	35–1	Lipa loam	0–25	San Pablo	Laguna
25	39–1	Macolod clay loam	0–20	San Pablo	Laguna
26	43–2	Lipa loam	Subsoil	San Pablo	Laguna
27	43–1	Lipa loam	0–25	San Pablo	Laguna
28	40–2	Lipa clay loam	40–55	San Pablo	Laguna
29	34–2	Lipa silt loam	40–70	San Pablo	Laguna
30	....	Lipa clay loam	40–55	Maquiling	Laguna
31	....	Lipa light silty clay loam	20–40	Maquiling	Laguna
32	....	.....	.....	Maquiling	Laguna
33	18–1	Lipa light silty clay loam	0–25	Sto. Tomas	Batangas
34	25–1	Lipa light silty clay loam	0–25	Sto. Tomas	Batangas
35	20–50	Lipa light silty clay loam	20–50	Sto. Tomas	Batangas
36	20–1	Lipa loam	0–30	Sto. Tomas	Batangas
37	21–1	Lipa clay loam	0–25	Sto. Tomas	Batangas
38	20–1	Lipa loam	0–30	Sto. Tomas	Batangas
39	1–24	Macolod clay loam	0–30	Sto. Tomas	Batangas
40	21–2	Lipa clay loam	40–65	Sto. Tomas	Batangas

TABLE 1 (continued)

Sample No.	Original stock number	Soil types	Depth	Origin	
				Locality	Province
			cm.		
41	18–1	Lipa light silty clay loam	0–25	Sto. Tomas	Batangas
42	....	Light clay	0–25	Calauan	Laguna
43	....	Clay	20–40	Calauan	Laguna
44	....	Macolod clay loam	20–45	Calauan	Laguna
45	....	Silty clay loam	0–20	Calauan	Laguna
46	....	Calumpang clay	0–35	Mamatid	Laguna
47	....	Calumpang clay	40–100	Mamatid	Laguna
48	....	Calumpang light clay	35–60	Mamatid	Laguna
49	....	Calumpang clay	0–25	Mamatid	Laguna
50	....	Sandy loam	40–80	Mamatid	Laguna
51	....	Lipa silty clay mud	40–100	Mamatid	Laguna
52	....	Putinglupa clay	0–22	Sto. Tomas	Batangas
53	R8–8a	Calumpang clay loam	25–40	Expt. Sta. C. A.	Laguna
54	R1–10a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
55	R11–20	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna
56	R5–11a	Calumpang clay loam	25–40	Expt. Sta. C. A.	Laguna
57	R10-11a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
58	R9-1a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
59	R6–11a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
60	R4–6a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
61	R7–9a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
62	R3-5a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
63	R6–7	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna
64	R1–8	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna

TABLE 1 (continued)

Sample No.	Original stock number	Soil types	Depth	Origin	
				Locality	Province
			cm.		
65	R9–11	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna
66	R5–10	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna
67	R8–11	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna
68	R2–7	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna
69	R2–11a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
70	R10–1	Calumpang clay loam	0–25	Expt. Sta. C. A.	Laguna
71	1–A	.....	.....	Lipa Hill	Batangas
72	....	Lipa clay loam	0–12	Tanauan	Batangas
73	....	Lipa clay loam	20–35		
74	I–D	.....	.....	Lipa Hill	Batangas
75	....	Lipa clay loam	0–15	Bulalo	Batangas
76	....	Lipa clay loam	20–40		
77	2–B	.....	30–55	Tombol Hill	Batangas
78	....	Lipa light silty clay loam	0–20	Alaminos	Laguna
79	2–A	.....	0–36	Tombol	Batangas
80	I–B	.....	28–60	Lipa Hill	Batangas
81	....	.....	55–150	Tombol	Batangas
82	I-B	Maquiling sandy loam	25–40		
83	7 (–5)	Heavy soil	0–30	Camp Mactan	Davao Penal Colony
84	10	Light soil	0–20	Centro	Davao Penal Colony
85	9 (–22)	Heavy soil	0–25	Camp Mactan	Davao Penal Colony
86	11 (–12)	Light soil	20–50	Centro	Davao Penal Colony
87	11–1	.....	0–30	Expt. Sta. C. A.	Laguna
88	11–1a	.....	30–42	Expt. Sta. C. A.	Laguna
89	10–1	.....	0–28	Expt. Sta. C. A.	Laguna
90	10–1a	.....	30–40	Expt. Sta. C. A.	Laguna

TABLE 1 (continued)

Sample No.	Original stock number	Soil types	Depth	Origin	
				Locality	Province
			cm.		
91	9–1	.....	0–30	Expt. Sta. C. A.	Laguna
92	9–1a	.....	30–52	Expt. Sta. C. A.	Laguna
93	8–1	.....	0–30	Expt. Sta. C. A.	Laguna
94	8–1a	.....	30–52	Expt. Sta. C. A.	Laguna
95	7–1	.....	0–28	Expt. Sta. C. A.	Laguna
96	7–1a	.....	28–44	Expt. Sta. C. A.	Laguna
97	6–1	.....	0–15	Expt. Sta. C. A.	Laguna
98	6–1a	.....	16–22	Expt. Sta. C. A.	Laguna
99	4–1	.....	0–30	Expt. Sta. C. A.	Laguna
100	4–1a	.....	30–46	Expt. Sta. C. A.	Laguna
101	3–1	.....	0–30	Expt. Sta. C. A.	Laguna
102	3–1a	.....	30–44	Expt. Sta. C. A.	Laguna
103	1–1	.....	0–20	Expt. Sta. C. A.	Laguna
104	2–1	.....	0–32	Expt. Sta. C. A.	Laguna
105	5–1	.....	0–15	Expt. Sta. C. A.	Laguna
106	I–C	.....	60–80	Lipa Hill	Batangas
107	R11–10a	Calumpang clay loam	25–50	Expt. Sta. C. A.	Laguna
108	R3–7	Calumpang clay loam	0–20	Expt. Sta. C. A.	Laguna

TABLE 2

Summary of results

SAMPLE NO.	APPARENT SP. GR.	REAL SP. GR.	MAXIMUM WATER-HOLDING CAPACITY	PORE SPACE	VOLUME EXPANSION	TOTAL SHRINKAGE	AIR-DRY MOISTURE
			per cent	*per cent*	*per cent*	*per cent*	*per cent*
1	1.165	2.004	48.00	51.50	13.94	29.50	6.07
2	1.105	1.946	50.90	56.90	21.42	35.30	9.07
3	1.062	1.917	56.60	51.40	13.70	16.30	7.39
4	1.083	1.771	44.30	48.00	14.90	31.00	6.07
5	1.136	1.995	47.60	57.70	20.74	42.50	8.91
6	1.158	2.025	46.20	52.60	17.00	42.35	7.28
7	0.831	1.835	52.70	66.80	15.88	24.95	9.06
8	1.147	1.964	53.80	45.80	18.34	45.60	8.03
9	1.125	2.072	50.60	61.60	34.72	77.50	13.25
10	1.076	1.826	48.70	48.80	19.79	48.90	9.44
11	1.147	2.142	49.10	55.80	18.54	42.70	8.04
12	1.216	2.065	42.60	51.10	17.14	25.40	7.93
13	1.263	2.177	36.80	47.20	12.74	11.85	5.47
14	1.145	1.781	46.20	43.50	13.68	18.75	8.89
15	1.018	1.773	57.50	56.60	23.49	39.75	10.29
16	1.188	2.154	43.50	52.90	13.64	13.25	6.66
17	1.216	2.204	42.40	53.00	20.73	35.80	5.64
18	1.180	1.931	43.40	51.90	20.44	39.55	9.23
19	1.116	2.073	56.90	50.80	23.98	75.10	9.14
20	1.199	2.157	47.80	57.90	23.53	47.15	9.28
21	1.101	1.990	58.00	59.10	26.88	58.80	11.02
22	1.207	2.175	52.10	58.90	29.16	41.65	9.58
23	1.119	1.734	42.70	48.40	19.89	44.60	8.90
24	1.086	1.987	47.00	52.50	10.47	24.80	7.17
25	1.115	2.102	46.10	55.10	12.15	26.40	6.26
26	1.248	2.139	38.20	46.70	6.20	13.70	5.44
27	1.146	2.211	44.80	51.40	7.08	36.45	4.16
28	1.076	1.957	45.10	48.80	7.97	9.40	5.11
29	1.158	2.061	46.20	56.50	19.32	35.50	12.04
30	1.106	2.079	52.10	56.90	16.37	46.00	5.33
31	1.232	2.031	49.10	57.50	28.60	47.85	12.29
32	1.200	2.084	42.70	49.10	12.62	17.80	6.13
33	1.187	1.953	42.70	50.80	16.33	37.15	7.57
34	1.164	1.940	44.90	51.40	18.52	29.75	7.42
35	1.216	2.150	49.00	57.90	26.62	46.40	12.45
36	1.272	2.147	36.80	46.60	13.26	16.45	4.22
37	1.094	1.758	45.90	50.30	19.96	33.60	9.73
38	1.359	1.997	30.60	40.30	10.24	19.35	4.04
39	1.182	1.813	41.30	46.20	20.83	52.00	7.26
40	1.050	1.829	50.50	53.30	18.07	34.90	12.45
41	1.215	2.022	40.00	49.90	13.62	35.60	7.44
42	1.189	1.860	41.60	49.96	17.68	18.35	7.11
43	1.279	2.396	50.76	60.02	27.40	44.25	11.34
44	1.277	2.235	48.35	57.12	29.56	61.00	11.11
45	1.192	2.002	40.57	47.75	14.05	41.40	6.82
46	1.176	2.066	30.63	51.93	16.01	37.80	7.84
47	1.184	2.060	47.61	52.46	18.94	34.30	7.61
48	1.093	1.820	49.56	52.96	23.69	42.75	10.55
49	1.210	2.165	49.43	56.57	20.11	21.50	10.35
50	1.246	1.986	37.40	46.22	15.39	9.78	5.60
51	1.171	2.071	50.27	53.38	23.42	30.65	9.84
52	0.883	1.971	63.30	54.40	3.00	24.05	8.55
53	1.263	2.001	61.90	60.10	19.45	112.75	10.09

TABLE 2 (continued)

SAMPLE NO.	APPARENT SP. GR.	REAL SP. GR.	MAXIMUM WATER-HOLDING CAPACITY	PORE SPACE	VOLUME EXPANSION	TOTAL SHRINKAGE	AIR-DRY MOISTURE
			per cent	*per cent*	*per cent*	*per cent*	*per cent*
54	1.310	2.344	53.60	62.10	41.69	99.00	13.21
55	1.312	2.307	55.90	60.70	41.91	99.10	12.10
56	1.324	1.877	46.50	57.60	48.64	111.25	14.16
57	1.314	2.158	53.00	59.20	42.54	54.75	12.42
58	1.356	2.453	45.00	60.00	26.56	66.55	11.61
59	1.303	1.948	51.70	54.10	42.36	90.50	12.67
60	1.300	1.976	57.10	56.80	50.93	107.00	6.54
61	1.309	2.197	55.70	59.20	43.44	110.00	12.43
62	1.254	1.935	51.90	55.60	39.54	118.10	11.32
63	1.149	1.842	58.80	53.00	41.73	68.00	10.58
64	1.199	2.267	55.60	60.00	36.95	64.35	13.77
65	1.247	2.360	54.50	60.60	30.63	61.55	12.58
66	1.354	2.467	54.70	61.60	41.08	61.90	10.14
67	1.195	1.422	56.50	63.40	38.01	64.00	10.44
68	1.215	1.884	53.20	56.00	39.25	57.70	12.00
69	1.202	2.104	56.10	59.30	34.78	51.50	10.70
70	1.083	2.094	48.07	56.00	34.98	62.75	10.42
71	1.090	1.540	46.70	44.00	19.47	62.00	9.32
72	1.128	1.986	43.60	51.40	11.17	31.10	7.70
73	1.187	2.110	45.50	54.80	16.78	28.40	8.81
74	0.931	1.981	60.50	60.20	9.62	23.25	10.42
75	1.242	2.204	41.30	51.20	13.45	28.35	6.39
76	1.057	2.028	56.80	57.80	20.05	34.30	9.06
77	1.215	1.957	47.60	54.70	31.55	67.75	10.57
78	1.282	2.039	43.80	51.50	23.24	31.30	9.27
79	1.256	2.081	39.40	46.40	16.35	37.70	10.35
80	1.121	1.761	55.20	63.00	36.94	84.35	17.21
81	1.091	1.942	57.30	59.50	24.32	46.25	12.49
82	0.912	1.773	56.00	60.70	12.81	—	9.59
83	1.153	2.205	60.90	62.80	29.44	116.25	10.57
84	1.128	1.996	48.50	53.50	15.92	33.10	7.34
85	1.179	2.295	70.70	65.50	44.16	55.85	12.10
86	1.146	2.209	53.20	56.35	22.58	50.50	8.57
87	1.141	1.482	44.60	50.80	14.93	89.80	6.40
88	1.072	1.909	50.00	63.20	13.77	21.70	8.26
89	1.143	1.916	44.00	49.00	13.79	25.30	6.78
90	1.308	2.438	43.50	57.10	21.58	49.65	10.14
91	1.154	2.041	39.60	49.60	10.80	35.35	6.81
92	1.196	2.000	47.40	61.60	25.86	63.70	10.02
93	1.178	1.959	42.30	49.20	14.70	29.50	5.78
94	1.172	2.001	46.00	52.50	17.20	54.55	6.95
95	1.164	2.064	45.70	51.80	17.46	30.30	6.57
96	1.227	2.184	47.30	56.50	24.38	54.40	9.99
97	1.110	1.692	42.40	47.10	11.60	25.25	5.43
98	1.103	1.819	47.60	51.30	27.70	92.25	10.43
99	1.177	2.013	42.30	50.20	14.76	32.90	6.54
100	1.234	2.109	45.60	55.20	25.51	25.91	9.63
101	1.049	1.725	43.50	45.50	12.80	28.50	6.60
102	1.262	2.305	47.70	57.30	24.18	50.75	9.85
103	1.212	2.073	42.40	51.60	16.10	28.65	6.85
104	1.114	1.948	43.70	49.90	11.71	31.55	7.16
105	1.164	2.013	43.40	50.70	12.26	33.20	6.67
106	1.000	1.736	49.85	54.95	23.86	35.90	12.49
107	1.338	2.178	45.29	56.82	32.71	72.60	10.38
108	1.281	2.086	42.55	54.68	25.94	63.15	12.48

TABLE 3

Ranges of variations of different soil constants for a number of Philippine soils

KINDS OF SOILS	MAXIMUM WATER-HOLDING CAPACITY	PORE SPACE	VOLUME EXPANSION	TOTAL SHRINKAGE	MOISTURE CONTENT AT AIR-DRY STATE
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Lipa clay loam	43–47	50–52	16–21	33–37	7–11
Lipa light	42–44	48–52	16–22	20–23	7–9
Silty clay loam		56–58		41–45	
Lipa loam	36–39	46–49	6–12	13–17	4–6
Calumpang	50–56	59–61	39–42	59–64	9–15
Clay loam		55–57			
Calumpang clay	46–50	51–53	18–24	36–46	9–11
E. S.	41–45	49–53	10–16	25–35	5–7

COLLEGE AND ALUMNI NOTES

Dr. Eulalio P. Baltazar, Assistant Professor, Department of Agronomy, resigned on October 15 to join the staff of the National Land Settlement Administration. Dr. Baltazar will assume the position of Assistant Supervising Agriculturist.

The Los Baños Biological Club met at a regular meeting on September 26. The following papers were read and discussed:

Dr. F. M. Sacay and F. R. Naanep. A study of farm, home, and community conditions in a farm village of Ilocos Norte as a basis for formulating a program of rural education.

Prof. E. F. Roldan. On the recent findings concerning cinchona canker.

Mr. Dominador Z. Rosell, '28, was recently sent to the United States as a government pensionado to pursue studies on soil technology at the Department of Agriculture at Washington, D. C. Mr. Rosell has been connected with the Soil Survey Division of the Bureau of Science.

Mr. Porfirio Manacop '33 was sent to the United States on September 4 as a government pensionado. He will pursue postgraduate studies on fishing at the University of Southern California. He has been with the Division of Fisheries, Department of Agriculture and Commerce.

The following papers were read and discussed before the regular meeting of the Los Baños Biological Club on October 31:

Dr. V. C. Calma. Deterioration of burned sugar cane.

Dr. J. M. Capinpin. Morphological and cytological variations in crop plants by colchicine treatment.

The following students, who were on the honor roll of the first semester, have qualified for scholarships for the second semester of

the current academic year: Full—Gregorio C. Fernandez and Bonifacio R. Niones; partial—Guillermo P. Santos, Pastor V. Manalo, Nemesio G. Tan, and Celestino P. Habito.

Gil P. Nones and Faustino T. Orillo, high school honor students admitted in June, were exempted from the payment of registration and laboratory fees in the second semester on account of having maintained a high level of scholarship.

The enrollment in the College in the second semester is 506, which is 52 less than that in the first semester. The Rural High School has 148 students, or 10 less than in the first semester.

Mr. Moises M. Kalaw, '25, was designated technical assistant for the National Coconut Corporation. He was assigned to supervise the activities of the corporation at Sariaya, Tayabas.

The Research Advisory Board of the College of Agriculture met for the first time on November 8. Among other matters, the board considered ways by which part of the activities in research may be directed toward participation of the College in the Seventh Pacific Science Congress to be held in Manila in 1943.

Dr. Nemesio B. Mendiola, Director of Research, is chairman of the board, and Dr. Francisco M. Sacay, secretary. All the departments of the College except English are represented in the membership of the board: Messrs. D. I. Aquino, Soils; S. M. Cendaña, representing Dean L. B. Uichanco, Entomology; R. B. Espino, Agricultural Botany; L. G. Gonzalez, Agronomy; G. O. Ocfemia, Plant Pathology; F. M. Sacay, Agricultural Education; F. O. Santos, Agricultural Chemistry; A. L. Teodoro, Agricultural Engineering; J. E. Velmonte, Agricultural Economics; and V. Villegas, Animal Husbandry.

The following are recent appointments in the Department of Agricultural Chemistry:

Dr. Julian Banzon, Assistant Professor of Agricultural Chemistry, effective November 1, 1940.

Mr. José M. Demeterio, Instructor in Agricultural Chemistry, effective November 1, 1940.

Miss Remedios O. Hizón, Instructor in Agricultural Chemistry, effective October 26, 1940.

THE EXPERIMENT STATION

LIST OF AVAILABLE CIRCULARS

Circular No. 2.—Bud Rot of Coconut (Revised, June, 1934) - - - *By G. O. Ocfemia*

Circular No. 3.—Experimental Errors and Application of the Probable Error to and the Interpretation of Experimental Results - - - - - - - - - - - - - *By Nemesio B. Mendiola* (Published as Chapter IV in *A Manual of Plant Breeding for the Tropics*, 1926, also sold by THE PHILIPPINE AGRICULTURIST at ₱3.25, paper bound, and ₱5.25, cloth bound, in the Philippines, and ₱3.50 and ₱5.50 elsewhere, postpaid.)

Circular No. 5.—Poultry Raising Made Easy (Revised) - - - - *By F. M. Fronda*

Circular No. 7.—How to Produce New Varieties of Gumamela (Hibiscus) - - - - - - - - - - - - *By Nemesio B. Mendiola*

Circular No. 8.—Horse Breeding in the Philippines - - - - - *By Valente Villegas*

Circular No. 9.—Fences for Farm Animals - *By B. M. Gonzalez and J. P. Esguerra*

Circular No. 10.—Practical Directions for Coffee Planting - - - *By Pedro A. David*

Circular No. 11.—The New College Copra Drier—Prepared in *Department of Agricultural Chemistry* with cooperation of *Department of Agronomy and Extension*. (Revised by *Moises M. Kalaw*).

Circular No. 14.—Beriberi: Its Causes and Prevention - - - - - *By F. O. Santos*

Circular No. 15.—Cattle Raising under Philippine Conditions - - *By Valente Villegas*

Circular No. 16.—A Simple Farm Record for the Farmer - - *By Francisco M. Sacay*

Circular No. 17.—College Trapnest - - - - - - - - *By F. M. Fronda and P. S. Paje*

Circular No. 18.—Surveying for Area with a Surveyor's Staff - *By Alexander Gordon*

Circular No. 19.—A Pageant: Illustrating the History and Growth of the College of Agriculture - - - - - - - - - *By Anne F. Cole*

Circular No. 20.—Amount of Nutrients in Philippine Food Materials - - - - - - - - *By F. O. Santos and S. J. Ascalon*

Circular No. 21.—Cassava Growing and Cassava Starch Manufacture - - - - - - - - - - - *By Nemesio B. Mendiola*

Circular No. 22.—Goat Raising - - - - - - - - - - - - - - *By Valente Villegas*

Circular No. 23.—Curing Pork and Making Sausage for Home Use - - - - - - - - - - - - - - - *By Mariano Mondoñedo*

Circular No. 24.—Construction and Operation of Silos in the College of Agriculture - - - - - - - - - - - - *By José P. Esguerra*

Circular No. 26.—Training Cattle and Carabaos for Work - - - *By Valente Villegas*

Circular No. 27.—Bunchy-top of Abacá - - - - - - - - - - - *By G. O. Ocfemia*

Circular No. 28.—Cotton Culture - - - - - - - - - - - - *By Eulalio P. Baltazar*

Circular No. 29.—Collegiate Education in Agriculture - - - - *By L. B. Uichanco*

Circular No. 30.—What Should Filipino Ornamental Gardens and Ornamental Plants Be? - - - - - - - - - - *By N. B. Mendiola*

Circular No. 31.—How to Slaughter and Dress Farm Animals - - - - - - - *By Valente Villegas and M. Mondoñedo*

The Circulars Nos. 1, 3, 4, 6, 12, 13, and 25 are out of print.

The price of the Circulars listed above is 10 centavos each except Nos. 5, 10, 16, 21, and 30 the price of which is 20 centavos.

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